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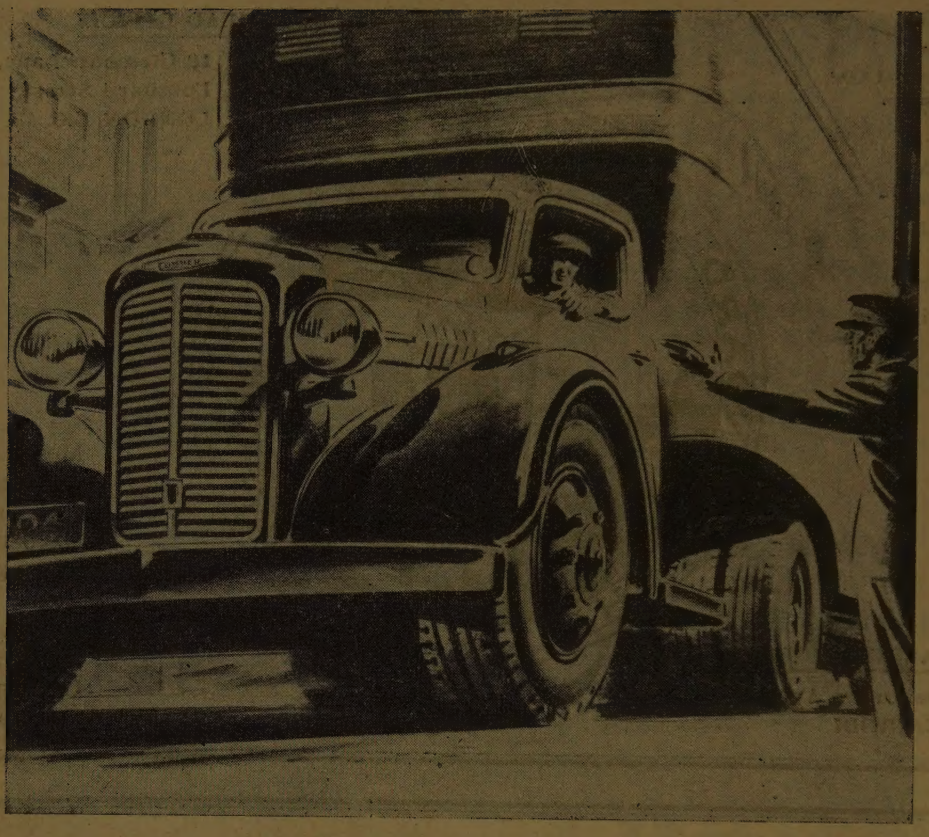

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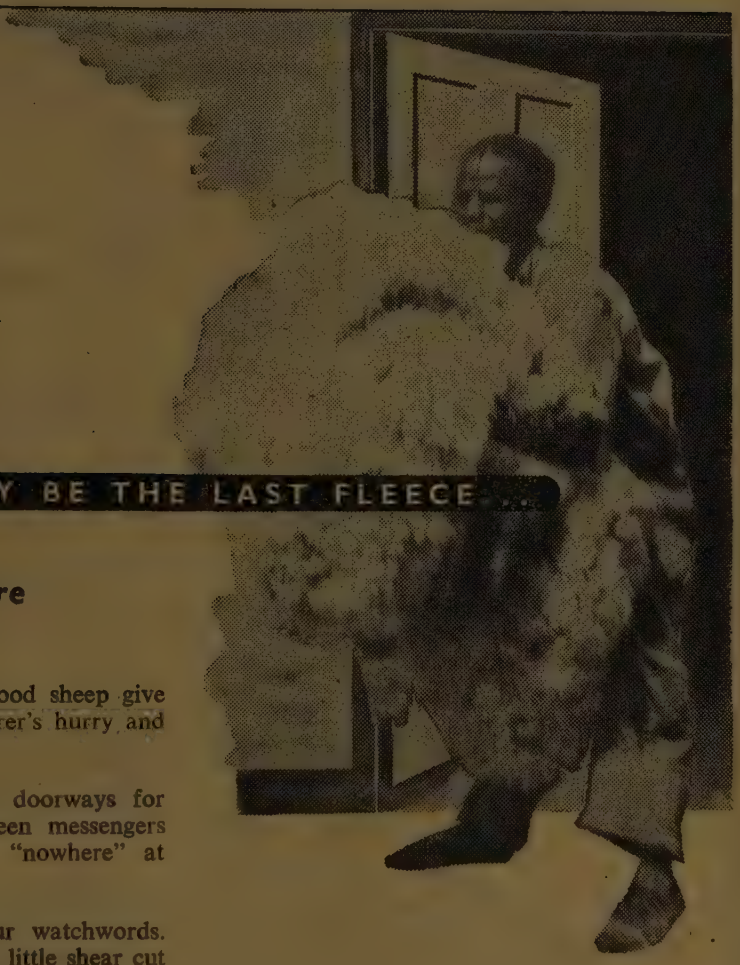

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THE

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the *Journal* or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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THE APPLICATION OF SCIENCE

In his Presidential Address to the British Association last year, Sir Henry Tizard discussed the balance between the pursuit and application of science, and it is of the utmost importance that we should adjust this balance in our efforts to increase food production in East Africa. In the bird's-eye view, we have at present two extreme methods of food production—the more primitive native tribes with their fatalistic scratching of an acre or two of unwilling soil, contrasted with the optimism and enthusiasm of the Groundnut Scheme, with its scientific determination to make fertile large areas which have hitherto been classed as unusable and uninhabitable.

It is now admitted that the forecasts of groundnut production under the new scheme were over-optimistic, and this has given rise to unjustified criticism of the planners of the scheme. No one could forecast accurately, in terms of pounds of groundnuts per acre, the results of applying scientific knowledge to the African bush, but the political system in the United Kingdom demands that annual production figures should be given when a scheme of this nature is submitted to Government. A great deal is known about the scientific principles of bush-clearing and of mechanized groundnut production, but the practical application of this knowledge in the utilization of vast areas of relatively unexplored country must inevitably be hindered by unforeseen difficulties. The brilliant success of atomic research during the recent war has coloured the public view of scientific investigations, for there we had an example of the rapid pursuit and almost instantaneous application of science. There is no doubt now that the gap between pursuit and application of science can be bridged in a short time, but that requires unlimited and untrammelled resources of money, man-power, and machinery, and these are rarely, if ever, available in peace-time. On this point Sir Henry Tizard says "It is a mistake to suppose that science advances rapidly in a war. Certain branches of science may receive a special stimulus; but on the whole the advance of knowledge is slowed. What is striking in war is the rapid solution of practical problems by the use of previously acquired scientific knowledge and technique". But there was no public outcry if the forecasts of atomic bomb production proved to be over-optimistic, and the pace of the investigation was not slowed by a scaling down of the financial resources because things were not going according to plan.

It is unfortunate, from the scientific viewpoint, that the system of control of public funds changes so rapidly from war to peace, for here is the greatest drawback to the pursuit and application of science for the public good. While the political necessity for the control of public money in peace-time must be admitted, the hampering effect of this on the application of scientific knowledge must also be appreciated, and public impatience must be tempered by the necessity for public thrift.

The need for a marked increase in food production in the African dependencies is recognized by all, and this was brought out in Sir Henry Tizard's address when he said "Whatever other countries may do, it is our bounden duty, and the only way of safeguarding our future so long as we remain a large food-importing country, to develop our colonial territories, particularly the underpopulated African colonies, where the increase in population that would follow the control of disease and the increase of food supply would open fresh markets for international trade". Elsewhere in this issue is published an abstract of a report on the Upper Tana River Irrigation Scheme, the aim of which is to provide new land for African agriculturalists, and the report shows both the possibilities and the difficulties which attend large-scale development of Colonial agriculture. After a very thorough investigation, two areas were selected for possible development, and irrigation schemes were prepared for these. The more favourable of the two schemes provides for the irrigation of 60,000 acres at a cost of nearly £11 million, or 180,000 acres at a cost of approximately £27 million. The costs per irrigable acre of these two schemes were worked out at £178 for the smaller scheme, and £151 for the larger area. On wartime financial standards the only question would be whether or not the larger area was required: on peace-time standards the chief question may be which, if any, we can afford.

But the application of existing scientific knowledge to colonial development requires an intermediate experimental stage, just as the application of an industrial discovery moves from the laboratory to the factory through a small-scale pilot plant. Taking as examples the Groundnut Scheme and the Tana Irrigation Scheme, we know how bush has been cleared in other countries, and how groundnuts have been planted and reaped mechanically in other parts of the world. We also know how irrigation has made fertile large areas of the world which were formerly sparsely populated and unproductive. It does not follow, however, that these tested methods will suit the conditions in East Africa, and the first stage must be to find out how known methods must be altered to suit local conditions. The ideal would be a pilot scheme, but a pilot irrigation scheme is rarely practicable and a pilot Groundnut Scheme would have delayed large-scale fat production for several years. The rapid large-scale application of scientific knowledge during the war has made the non-technical administration and the public impatient with cautious scientific forecasts, but they are just as critical of over-optimism by technical advisers "who ought to know better". Sir Henry Tizard said "This is the time for adventure: for taking risks. Calculated risks, of course; but not so nicely or so lengthily calculated that they are taken too late". This is a challenge both to scientists and to the financial advisers who tend to expect their scientific counterparts to forecast the results of each year's investigations and so calculate nicely the money, men and materials which will be required some years ahead. Going back to the Tana River Scheme, anyone with a sound knowledge of tropical agriculture could name the most suitable crops for the area and, assuming a yield per acre based on figures from similar conditions, could calculate the number of families who could support themselves and the volume of food which could be exported from the district to supply other parts of East Africa. These would be guesses—intelligent guesses—but they would almost certainly be wrong, because no one can forecast what will happen when Man attempts to bring Nature to heel. If these guesses were used merely to decide whether or not the scheme is feasible and not as accurate forecasts of the results of the work, they would be of great value, but the keynote thereafter would be financial determination to make the scheme a success even although the guesses fell short of the truth.

Reckless abandon in the control of public money would lead to chaos, but the spirit of adventure must permeate the financial circles before scientific knowledge can be applied with real speed and enthusiasm.

D.W.D.

THE TANA RIVER IRRIGATION SCHEME

A recent report published by the Hydraulic Branch of the Public Works Department, Kenya*, surveys the possibilities of a large-scale irrigation project on the Tana River, the largest river in Kenya, which has always claimed the attention of people interested in the development of the country. Some years ago the subject was examined by Messrs. Harris and Sampson, and their "Report on the Tana River Expedition, 1934" was used as a foundation for the present survey. Harris and Sampson divided the Tana River into three reaches—the Lower, Middle, and Upper Tana, and they dealt with the Flood Plain separately. This subdivision has been adhered to in the report under review, "the Lower Tana" referring to the stretch from Garsen to the sea; "the Middle Tana" from Bura to Garsen; "the Upper Tana" from Grand Falls to Bura; while "the Flood Plain" refers to alluvial deposits on the banks of the river, roughly three miles wide, almost all of which is below maximum flood level.

Before dealing in detail with the Upper Tana River, the report summarizes the reasons why the Lower and Middle sections and the Flood Plain are unsuitable for irrigation projects. As regards the Lower Tana, the river flows in its last hundred miles upon a ridge with lower land on either side. This is usual for deltaic rivers, and any large scale development of the area could only be achieved by combination of protection and irrigation. Any such works would be enormously expensive and would be a continual source of anxiety owing to the unstable nature of the river and the consequent risk of a sudden change in its course. It has been proved both in India and America that works of this nature are likely to result in the deterioration and ultimate ruin of the land which they are intended to protect.

Two reasons are given why the Middle Tana area is unsuitable for development by irrigation. In the first place, the construction of headworks anywhere in this reach would be enormously expensive owing to the instability of the river and its consequent liability to change its course. Secondly the river bed slopes so gently in this middle reach that only a very small area of land would be commanded by an irrigation scheme.

The Flood Valley was also examined in regard to its suitability for an irrigation project, but it was found that in places the ground falls steadily from the river bank to a swamp, the water in the swamp being no less than eleven feet below the level of the river bank. Throughout the whole area the river appears to be in a state of unstable equilibrium; it flows in the middle of the valley, gradually raising its bed until it has reached its present elevated position. In due course, it will burst its banks and take a new course, which will in turn be raised until it is unstable. To interfere with these natural conditions by attempting to confine the river to one course would be to court disaster.

The whole area of the Upper Tana River was thoroughly explored and roughly mapped, with special reference to the various soil deposits, up to a distance of approximately 30 miles on both sides of the river, the total area covered being approximately 6,000 square miles. The Soil Chemist of the Department of Agriculture examined some hundreds of soil samples, and his report is published as an Appendix to the hydraulic survey. Since it seemed feasible to prepare a tentative irrigation scheme for this area, a more detailed investigation was carried out which included geology, meteorology, water resources, conveyance losses, storage possibilities, and soils, and as a result two schemes were suggested.

Scheme No. I was selected chiefly because it contains the most promising soils seen, and it consists of some 116,000 acres of red and rather sandy soil, adjoining an almost unlimited extent of rather heavier and more clayey soils. The length of the main canal would be 204 miles, and it would have to cross 146 watercourses. The total capital cost of this scheme, for an unlined canal, and allowing for compensation water, is estimated to be £10,718,700, or £178 per acre of irrigable land (60,000 acres in all). For a concrete canal, and allowing no compensation, the total cost is estimated at £27,173,350 or £151 per acre of irrigable land. (180,000 acres in all.)

Of the red sandy soil which occurs in this scheme the Soil Chemist says "The utilization of this ochre-red soil type is severely limited due to the limited depth of the sandy soil over

* Report on the Upper Tana River Irrigation Project, October, 1948, Price Sh. 5, Government Printer, Nairobi.

the secondary kunkar horizon that occurs about one to five feet or more below the soil surface. This soil contains 60 to 70 per cent of coarse sand, about 20 per cent of fine sand, with about 10 to 20 per cent only of silt plus clay, but the small clay fraction is very effective in giving body to the soil and in retarding a too rapid percolation of water . . This soil type taken to 24 inches has been used for pot culture work using maize and beans. Both crops have made very poor growth, the plants being dwarfed and yellowish, thus indicating a great scarcity of available nitrogen. The fertility of this soil would have to be built up by organic manuring and a special system of cropping".

The heavier soil which also occurs in Scheme No. I was reported on by the Soil Chemist as follows "In the case of this soil type, with few exceptions, the soil texture is suitable and there is ample depth . . . A soil sample representing the uppermost 28 inches of about average texture for the soil type contained 50 per cent of coarse sand and 15 per cent of fine sand, leaving 35 per cent for silt and clay . . . Phosphate and potash reserves are good, but organic matter and nitrogen supplies are low to very low and would have to be built up . . . In plot culture trials growth was better than in the case of soil type I [the other soil type in Scheme No. I] but there was an evident lack of available nitrogen. This soil type, which is very extensive, is likely to be the most promising for general cropping under irrigation".

Scheme No. II, the only alternative scheme which was considered as at all possible, is sited on the plains near Bura, and would require a canal nearly 200 miles long, which would pass along the eroded sides of the valley nearly all the way. The area irrigable from an unlined canal, and allowing for compensation water, is estimated to be 48,000 acres, of which approximately 8,000 acres could be double-cropped, and the estimated total capital cost would be £5,806,690, or £121 per acre. For a concrete lined canal, allowing no compensation water, the area would be 108,000 acres, of which 43,000 acres could be double-cropped, and the cost is estimated at £19,507,240, or £180 per acre.

The most extensive soil type in Scheme II is a dark grey impervious clay loam, ranging to sandy loam, which loses its structure when wetted and becomes a sticky paste. To quote the Soil Chemist's report "Trials have shown that the excessive water gradually drains away and that on drying this soil forms a close network of fine cracks from the surface downwards, thus aiding soil aeration. Though almost bare of any vegetation in situ and having very adverse physical properties using arbitrary laboratory tests, the disturbed soil in pot culture work did produce a fair growth without the usual signs of severe waterlogging . . . The soil is well supplied with phosphate and potash. The soil nitrogen varies between .020 per cent and .025 per cent, and, in the laboratory, the lack of nitrogen symptoms was not very marked. However, performance in situ with many feet of impervious heavy soil which would hold up irrigation waters and which develops the properties of a fluid would have to be determined by field experiments".

The other soil type in Scheme No. II occurs at an extreme distance from the canal intake and is not extensive. It consists of old alluvia or an old flood plain of the Tana River, and contains from 0.5 to 1.0 per cent soluble salts. The more saline areas of this type would be unsuitable for irrigation, and a more detailed survey of the extent to which this soil type occurs would be required before Scheme No. II could be implemented. In his report the Hydraulic Engineer says "The really doubtful aspect of this scheme is the suitability of the land for irrigation. As previously stated, the soils on either side of the river are heavy, clayey, and more or less impervious, and they would most probably be unsuitable for crops requiring reasonably well drained and aerated soils. Due to the nature of the soils, and the fact that the land is almost level, artificial drainage would be so costly as to be impracticable, and it would seem that the only crop which might be successfully grown would be swamp rice, though this would have to be proved by experiment".

After weighing the technical and financial considerations very carefully, the conclusion is reached that the possibilities of irrigation from the Upper Tana River are most unfavourable, the factors against this being the excessive cost of any scheme, the poverty of the soil and the remoteness of the area. Comment must be made on the thoroughness of the investigation in spite of these major drawbacks which must have been obvious early in the work.

D. W. DUTHIE.

TREATMENT AND DISPOSAL OF WASTE WATERS FROM PROCESSING OF COFFEE

By T. W. Brandon, Water Pollution Research Laboratory, Watford, England

(*Received for publication on 24th February*, 1949)

For several years concern has been felt in East Africa about the pollution of streams by effluent discharged from coffee factories. The position has been aggravated by sub-normal rainfall and it has not infrequently happened that the product of one coffee factory has been tainted by the presence in its water supply of effluents discharged by other factories higher up the same stream.

Between 1935 and 1939, a Committee appointed by the Water Board of Kenya investigated means of disposal of coffee effluents and published an interim report [1]. Among the recommendations were that tank washings, together with effluent draining from fermentation tanks during pulping (tank effluent), should be discharged to seepage pits, and that the pulp heap should be so sited that the very polluting liquid draining from the pulp could not flow into streams. There is no doubt that a great improvement in the condition of the rivers could be achieved by adoption of these recommendations, but it was realized that much polluting matter would still be discharged from the factories. Arrangements were therefore made in 1946 for the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research of Great Britain to undertake an investigation of the problems involved.

Volume and Composition of the Waste Waters

Details of the volume and composition of waste waters produced at a Kiambu factory during the main picking season in 1946 are shown in Table I. Picking was concentrated into an unusually short period during this season, and insufficient water was available for the customary volume of 20,000 gallons per ton of clean coffee to be used during factory operations. Instead, about 13,500 gallons were used per ton, with the main result that less polluting matter than usual was removed from

TABLE I

Average Results of Examination of Waste Waters from Processing of Coffee (Main Crop, 1946)

Waste Water	Volume (gallons per ton of clean coffee)	Proportion of total volume (per cent)	Biochemical oxygen demand* in three days at 26·7°C. (parts per 100,000)	Proportion of total polluting matter (per cent)
A.—Waste Waters Produced during Pulping—				
Pulp Water	4,490	34	240	45
Main Tank Effluent	2,220	17 } 57	390	35 } 85
Repasser Tank Effluent	840	6	145	5
B.—Waste Waters Produced during Tank Washing—				
First Tank Wash	280	2	280	4
Second Tank Wash	270	2 } 5	130	1 } 6
Repasser Tank Wash	165	1	190	1
C.—Waste Waters Produced during Channel Washing—				
Main	4,740	35 } 38	40†	8 } 9
Repasser	440	3		1
Totals	13,445	100	—	100

*Note.—Biochemical oxygen demand (B.O.D.) is a measure of the quantity of oxygen which would be absorbed by the liquid when discharged to a river. By comparison, the average B.O.D. of crude domestic sewage is about 40 parts per 100,000. Samples of liquid draining from a pulp head had an average B.O.D. of about 1,400 parts per 100,000.

†5 to 10 when water was plentiful during July to September season.

the fermented beans during washing in the tank, and more during washing in the channel (Table II).

TABLE II

PROPORTION OF TOTAL POLLUTING MATTER PRODUCED IN DIFFERENT FACTORY OPERATIONS DURING THE TWO SEASONS OF 1946

OPERATION	July to September	October to December
Pulping	84.6	85.1
Washing in Tank	12·7	5·9
Washing in Channel	2·7	9·0
TOTAL, ..	100·0	100·0
Total volume of water used (gallons per ton of clean coffee)	19,680	13,445

It appeared, however, from a comparison of results obtained during the two seasons of that year, that the total weight of polluting matter from a given weight of cherries is largely independent of the volume of water used.

The most polluting liquid was main tank effluent; nearly as polluting were first tank washings and pulp water. About 80 per cent of the total polluting matter was contained in pulp water and main tank effluent together. The mixed waste waters were equivalent in polluting character to about 60,000 gallons of crude domestic sewage for each ton of clean coffee produced per day.

TREATMENT OF THE WASTE WATERS

Seepage Pits.—It was recommended in the previous investigation [1], that tank effluents and tank washings should be discharged to seepage pits. By adopting this method, about 46 per cent of the total polluting matter, as measured by the test for biochemical oxygen demand, contained in about 28 per cent of the total volume of water, could be disposed of. There is no doubt that where the loss of this volume of water is not a serious matter, and where soil and other topographical conditions permit, the use of seepage pits affords a cheap and convenient means of disposal of these particular effluents. This method is, however, only a partial solution to the problem and one which could not be applied at every estate, and some other means of treatment would be required in most cases.

Rapid Separation of Pulp from Pulp Water.—Normally, pulp is flumed away from the factory and separated by screening at distances up to 100 ft. from the pulper. Rapid leaching of soluble substances from the freshly split pulp occurs during this operation, and some experiments were made to determine the effect of period of contact with pulp on composition of pulp water. The results (Table III) show that the polluting character of the liquid, as measured by the test for biochemical oxygen demand, was nearly doubled during the first 15 seconds of contact, but increased subsequently much more slowly.

TABLE III

EFFECT OF PERIOD OF CONTACT WITH PULP ON COMPOSITION OF PULP WATER

Period of contact after leaving pulper (seconds)	Oxygen absorbed from N/80 acid permanganate in four hours at 26·7°C.	Biochemical oxygen demand in three days at 26·7°C.
	parts per 100,000	
0	114	99
15	154	170
30	172	180
60	191	194
120	211	213

Obviously, to be effective, separation of pulp from fluming water must occur very close indeed to the pulper. By rapid separation, approximately 40 per cent of the pollution from this source could be avoided. This is equivalent to nearly 20 per cent of the polluting matter in the total waste waters produced during processing of coffee. Rapid separation and removal of pulp by mechanical means would not always be easy, but it should be practicable at many estates to remove the separated pulp in wagons or by conveyor belt or screw conveyor.

Natural Fermentation.—Laboratory experiments (Table IV) have shown that the polluting character of the waste waters can be considerably reduced by allowing the liquid to stand and ferment. The polluting character of the mixed waste waters was reduced by approximately 70 per cent by storage in dishes for six days and by about 85 per cent by storage for 12 days. Where the tank effluent and tank washings can be discharged to seepage pits the chief remaining source of pollution is pulp water. By natural fermentation in dishes, the polluting character of this liquid was reduced by about 60 per cent in eight days and by nearly 80 per cent in 12 days.

TABLE IV

AVERAGE RESULTS OF TREATMENT OF WASTE WATERS BY NATURAL FERMENTATION

Period of fermentation (days)	Oxygen absorbed from acid permanganate in four hours at 26·7°C. (O.A.)	Biochemical oxygen demand in three days at 26·7°C. (B.O.D.)	Reduction in polluting character (per cent)	
	parts per 100,000		Based on O.A.	Based on B.O.D.
A.—Mixed Waste Waters—				
0	174	176	—	—
1	107	152	39	14
2	91	114	48	35
4	64	80	63	55
6	36	55	79	69
8	32	33	82	81
12	28	27	84	85
B.—Pulp Water—				
0	236	187	—	—
1	213	165	10	12
2	199	157	16	16
3	160	133	32	29
5	131	97	45	48
8	96	70	59	63
12	83	43	65	77

If this method was to be used on a large scale, it would be necessary to construct a storage pond of sufficient capacity to provide the necessary period of retention. For example, to provide a fermentation period of eight days at a factory producing one ton of clean coffee per day and consuming 20,000 gallons of water for each ton of coffee produced, a storage pond or lagoon with a volume of 160,000 gallons would be required. Such a pond could be about 10 ft. deep, 30 ft. wide and 90 ft. long and the waste waters would pass continuously through this pond during the processing season. Difficulties might arise, however, in operating this method at a factory and it should be tested on a large scale. An opportunity would then also be afforded for an assessment of any public health problems which might arise. For example, such lagoons might possibly serve as breeding grounds for malarial mosquitoes, and there might be some odour nuisance, although this did not occur during the laboratory experiments.

Chemical Treatment.—Results of treatment of the mixed waste waters with chemical coagulants (Table V) show that the biochemical oxygen demand could be reduced by up to 50 per cent by this method, but the oxygen absorption from acid permanganate was not reduced by more than 18 per cent. The sludge produced was frequently bulky and would not settle readily. Close chemical control would be necessary, and the liquid remaining after treatment would still be quite polluting. It was concluded that addition of coagulants would not be a suitable means of treatment for these waste waters.

TABLE V

RESULTS OF TREATMENT OF WASTE WATERS WITH COAGULANTS

Coagulant	Concentration of coagulant (parts anhydrous compound per 100,000)	Volume of settled sludge (per cent)	pH value of liquid after treatment	Reduction in polluting character (per cent)	
				Based on oxygen absorption	Based on B.O.D.
Calcium hydroxide ..	40	30	9·6	14	40
	80	15	10·0	15	49
Ferrous sulphate ..	40	18	6·0	5	30
	80	27	5·8	7	33
Ferric chloride ..	20	15	4·8	8	40
	40	25	3·9	18	49
	80	15	3·5	14	40
Aluminium sulphate	20	11	5·1	5	17
	40	40	4·7	2	2
	80	35	4·5	2	48

Biological Filtration.—From a consideration of the nature of the waste waters, it seemed probable that they could be purified by biological filtration*. Preliminary experiments were made on the Kiora Estate, Kiambu (by courtesy of Mr. C. D. Gee and Mr. N. R. Solly) using four small filters each containing 2 cub. yds. of filtering medium, over which liquid was distributed by pumping through grids of perforated pipes. Subsequently, experiments were made at Ruiru (by courtesy of Mr. R. E. Rodseth), using a filter containing 50 cub. yds. of filtering medium, and equipped with a revolving distributor. A small coffee factory (Figs. 1 and 2) was erected on the site, and coffee was brought from convenient estates and pulped in a 4-port, drum-type pulper. The pulp was screened immediately below the pulper and pulp water was discharged to a tank, 1,000 gallons in capacity in which it could be mixed with other waste waters. Beans from the pulper, together with a small proportion of unseparated pulp, were passed along a galvanized iron trough and then through a perforated plate (coffee screen) into one of five wooden fermentation tanks, each 4 ft. long, 1 ft. 6 in. wide, and 2 ft. deep. Tank effluent was discharged through screens to the waste water mixing tank. As a result of the rapid separation of pulp from fluming water, the pulp water was much less polluting than that produced at a typical factory, where the mixture frequently flows along a flume up to 100 ft. long before separation. In order to simulate factory conditions as nearly as possible, all the pulp was stirred with water for approximately one minute and the liquid was immediately drained off to the waste water mixing tank. The beans were allowed to ferment for between 24 and 48 hours, and were then washed to remove products of fermentation. This was done by adding a measured volume of water, stirring vigorously with paddles, and discharging the washings through screens to the mixing tank. A second washing was given in the same manner. A third washing was given in the tank, either immediately after the first two washings or somewhat later, according to conditions. During the third washing, the beans were washed repeatedly with several batches of water, with thorough stirring, and "light" beans and particles of pulp and husk were removed by skimming with wire gauze. The volume of mixed waste waters in the tank was if necessary made up to 1,000 gallons by adding water and the liquid was well mixed.

For satisfactory working, the biochemical oxygen demand of liquids applied to biological filters should not be much greater than 30 parts per 100,000. The mixed waste waters, which had a biochemical oxygen demand varying between about 110 and 180 parts per 100,000, were therefore run through a gauging box into a small mixing tank, at a rate of 1,000 gallons a day, and effluent returned from the filter was run into the mixing tank at a rate of 4,000 gallons a day, thus diluting the mixed waste waters with four times their own volume of filter effluent. The diluted liquid was pumped to the filter at a rate of 100 gallons per cub. yd. per day. The total volume of liquid flowing through the filter was 5,000 gallons a day; 4,000 gallons of effluent per day were returned to dilute the mixed waste waters, and the balance of 1,000 gallons per day was run into the effluent storage tank and used in factory operations when required. The effluent storage tank was divided into two sections connected at top water level. Any make-up water was added to the section farther away from the humus tank; from this section, liquid used for washing fermented beans was taken. The average volume of make-up water was about 100 gallons per day, that is, about 10 per cent of the total volume of water used in processing.

Coffee cherry was collected from two estates during investigations with the larger filter; in each case, the cherry had been picked late on the previous day and had undergone some fermentation during storage overnight, particularly towards the end of the season, when the cherry was a little over-ripe. Moreover,

* In biological filtration, the liquid is passed through a bed of broken stone or other suitable hard material, on which a film of bacteria, fungi, and other organisms has been established. Purification of the liquid takes place during contact with the film, which is readily established by circulating river water through the filter for two to three weeks before the start of each picking season. Since the intensity of picking gradually increases as the season progresses, the active film is well established before it becomes necessary to deal with the maximum loading.

it was not possible to incorporate a repasser pulper in the experimental plant, and a greater proportion of beans than normal was discharged with the pulp. It has therefore been considered preferable to take as a basis for calculation not the actual number of *debes** pulped per day in the experimental plant, but the equivalent number of *debes* calculated from the biochemical oxygen demand of the mixed waste waters, compared with the biochemical oxygen demand of mixed waste waters at a typical factory during normal working in the 1946 season.

Results of operation of the experimental plant (Table VI) indicated that the whole of the mixed waste waters from processing the equivalent of 28 to 46 *debes* of coffee cherry per day could be treated in the experimental filter, but the degree of purification gradually decreased as the number of *debes* increased. To treat the mixed waste waters from a factory producing one ton of clean coffee per day, a biological filter containing between 650 and 1,000 cub. yds. of filtering medium would be required, depending on the degree of purification considered necessary from a study of local conditions.

Cost of Treatment of Waste Waters.—It would appear that by far the most satisfactory method of treatment of the mixed waste waters would be by biological filtration. Alternatively, treatment by natural fermentation, for example by retention in ponds or lagoons, might be employed, should this latter method prove satisfactory on a large scale.

Table VII, based on figures kindly supplied by the Hydraulic Engineer, Public Works Department, Nairobi, shows comparative capital costs of providing means of treatment of the waste waters by different methods, based on present costs in the Nairobi District, and allowing for contractor's profit. Costs could probably be reduced by employing direct labour, particularly if aggregate suitable for use in a biological filter were available in the district.

TABLE VI

AVERAGE RESULTS OF OPERATION OF BIOLOGICAL FILTER TREATING WASTE WATERS FROM EXPERIMENTAL COFFEE FACTORY

(One volume mixed waste waters diluted with four volumes filter effluent and applied to filter at a rate of 100 gallons per cubic yard of filtering medium per day)

PERIOD	10th to 24th December, 1947	28th December, 1947, to 12th January, 1948	27th January to 17th February, 1948	14th to 25th January, 1948
Estate	*A*	*A*	*B*	*B*
Coffee cherry pulped per day (*debes*) ..	30	40	30	40
Oxygen absorbed from acid N/80 KMn04 in four hours at 26·7°C. (parts per 100,000)—				
Mixed waste waters	101	127	153	178
Mixed liquid applied to filter ..	18	29	34	42
Settled effluent from filter	1·4	2·3	5·0	6·2
Biochemical oxygen demand in three days at 26·7°C. (parts per 100,000)—				
Mixed Waste Waters	113	135	152	185
Mixed liquid applied to filter ..	27	33	36	45
Settled effluent from filter	1·7	4·2	7·3	10·4
Reduction in polluting character (per cent)—				
Based on oxygen absorbed ..	99	98	97	97
Based on biochemical oxygen demand	99	97	95	94
Equivalent number of *debes* coffee cherry per day*	28	34	38	46

*Assuming mixed waste waters from processing of one ton clean coffee (600 *debes* cherry) to be equivalent to 60,000 gallons crude domestic sewage, with B.O.D. 40 parts per 100,000.

(* *Debe*, a four-gallon petrol tin.—*Ed.*)

TABLE VII

COMPARATIVE CAPITAL COSTS OF ALTERNATIVE SCHEMES FOR TREATMENT OF WASTE WATERS FROM PROCESSING OF COFFEE

Waste waters treated	Method of treatment	Reduction (per cent)		Capital cost for factory producing one ton of clean coffee per day*
		in polluting character of waste waters treated	in total pollution	
				£
Scheme I— Tank effluents and tank washings ..	Seepage pits	—	46	£45
Scheme II— Tank effluents and tank washings ..	Seepage pits	—	46	45
Pulp water and channel washings ..	Biological filtration	94	51	1,000
Totals ..			97	£1,045
Scheme III— Mixed waste waters ..	Fermentation for 12 days	85	85	£580
Scheme IV— Mixed waste waters ..	Fermentation for 12 days	85	85	580
	Biological filtration after fermentation	94	14	480
Totals ..			99	£1,060
Scheme V— Mixed waste waters ..	Biological filtration to produce effluent with B.O.D. about ten parts per 100,000	94	94	1,850
	Biological filtration to produce effluent with B.O.D. about four parts per 100,000	98	98	2,500

*Cost in Nairobi district, April, 1948, allowing for contractor's profit.

Treatment of tank effluent and first and second tank washings in seepage pits would remove about 46 per cent of the total polluting matter at a capital cost of only £45 for a factory producing one ton of clean coffee per day. The other waste waters could, however, still cause considerable pollution in the small rivers normally found in Kenya and secondary treatment would be required at most estates. Treatment of the total mixed waste waters by biological filtration so as to reduce the polluting character by about 94 per cent would cost about £1,850 for a factory producing one ton of clean coffee per day; the filter could be 6 ft. deep and about 30 ft. radius. If a greater degree of purification were considered necessary, a correspondingly larger filter would be needed. For example that required to reduce the total polluting character of the waste waters by 98 per cent, would cost about £2,500 for a factory producing one ton of clean coffee per day.

Biological filters have been used for treatment of sewage and trade wastes in Great Britain since about 1900. Provided suitable material is chosen it should never become necessary to renew the filtering medium. In this connexion arrangements have been made for samples of typical East African aggregates to be sent to England so that their suitability for use in biological filters may be assessed. It will, of course, be necessary to repair or replace mechanical equipment, such as pumps and revolving distributors, after use for many years.

If the waste waters can be given treatment partly in seepage pits and partly by biological

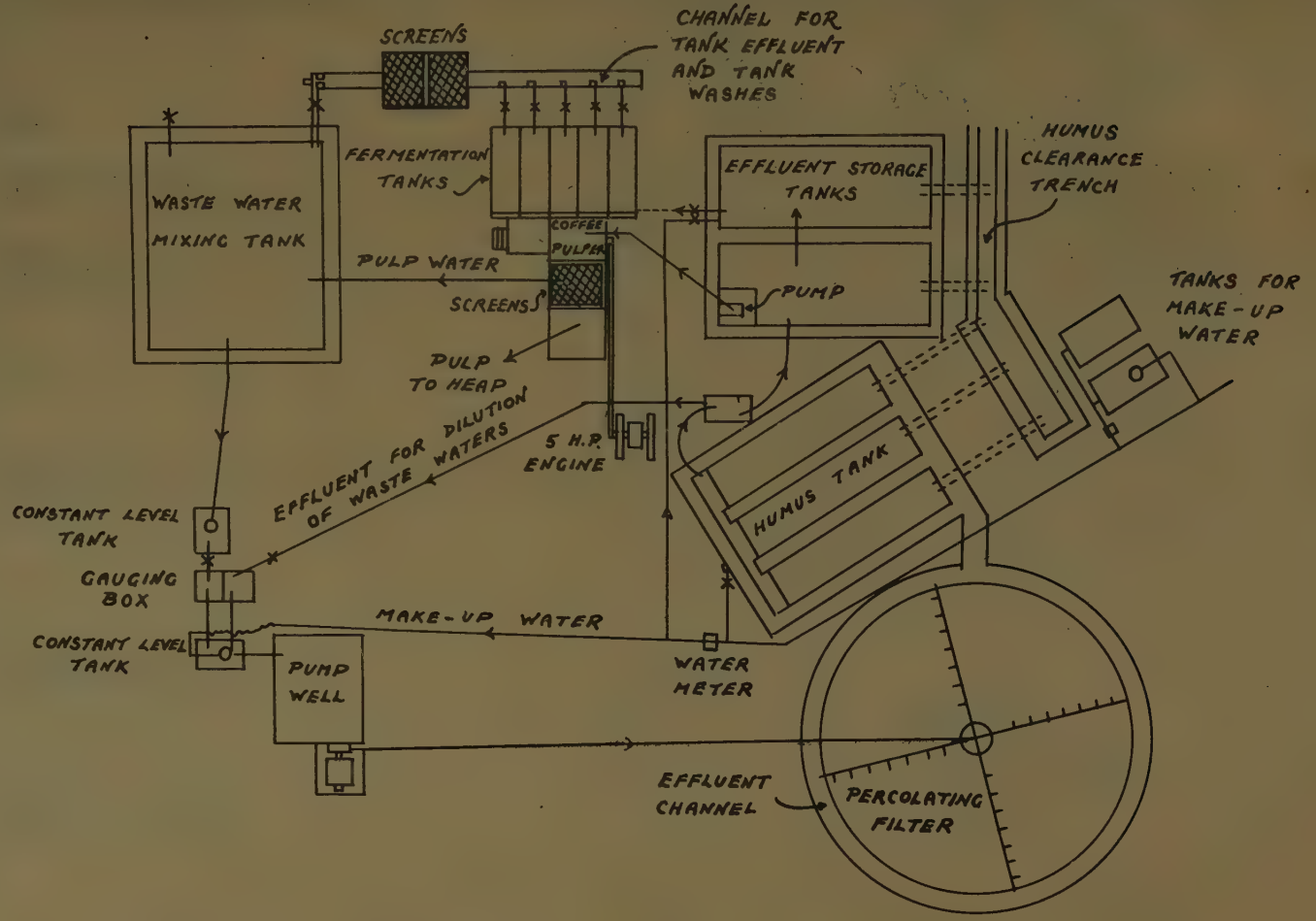

FIG. 1—Layout of experimental plant for treatment by biological filtration of waste waters from processing of coffee.

FIG. 2—Experimental plant for treatment of waste waters by biological filtration.

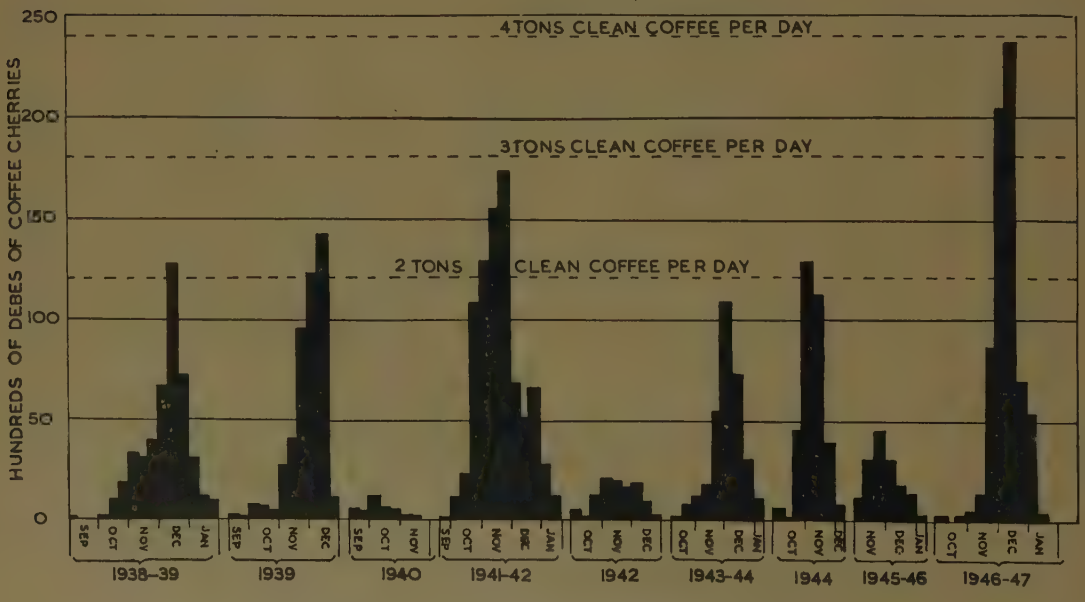

FIG. 3—Production of coffee at Kabazi Estate, Kiambu.

filtration (Scheme II) or treatment by natural fermentation followed by biological filtration (Scheme IV) the capital cost of works for complete treatment might be reduced to about £1,100 for a factory producing one ton of clean coffee per day.

The degree of purification required should be based on a consideration of local conditions; for example, the degree of dilution available in the river to which the effluent is discharged, and the requirements of other riparian owners.

In deciding the size of treatment plant required at a particular factory, reference should be made to the production of clean coffee at the factory over a period of several years. For example, for Kabazi Estate, Kiambu (Fig. 3, based on figures kindly supplied by Mr. N. R. Solly) it would probably be most satisfactory to base the size of treatment plant on a production of two tons of clean coffee per day, that is, on a probable volume of 30,000 to 40,000 gallons of waste waters per day. It would obviously be uneconomic to base the size of plant on the maximum crop to be expected in occasional years, for example, in 1941–42 or in 1946–47.

The cost of treatment would be partly offset by the advantage of having available at the factory an additional supply of reasonably clean water which could in most circumstances be re-used in factory operations (*see* next section).

Effect on Coffee Quality of Using Filter Effluent for Factory Operations

Where water resources are limited, it would be of considerable advantage if the waste waters, after treatment, could be re-used in factory processes. It is essential, however, that treated effluent, if re-used in this way, should convey no harmful taint to the finished coffee. In collaboration with the Jacaranda Coffee Research Station, some small-scale experiments to test the effect on coffee quality have been made during the course of this investigation.

In the first experiment, a batch of coffee cherry was divided into seven similar portions. One portion was pulped, fermented, and washed with diluted waste water as applied to the four small filters at Kiambu, four portions were similarly processed with effluent from each of the four filters, one portion was processed with river water and one with tap water to serve as a control. The beans were dried and duplicate samples from each portion were submitted to the liquorer of the Coffee Board of Kenya, Mr. C. R. Devonshire, for liquoring tests. The results obtained on the duplicate samples were as follows:—

Liquid used for Processing Coffee	*Quality of Coffee Liquor*
Diluted waste waters (as applied to filters)	*a.* Foul. *b.* Very foul.
Effluent from Filter 1	*a.* Slight taint. *b.* Slight taint.
Effluent from Filter 2	*a.* Clean. *b.* Clean.
Effluent from Filter 3	*a.* Clean. *b.* Clean.
Effluent from Filter 4	*a.* Clean. *b.* Very slight taint.
River water (Kiu river)	*a.* Clean. *b.* Clean.
Tap water (Kabete)	*a.* Clean. *b.* Slight unpleasant flavour.

The filter effluents used in this experiment absorbed between two and four parts of oxygen per 100,000 from acid permanganate and had values for biochemical oxygen demand between three and ten parts per 100,000. The river water had an oxygen absorption of 0.3 part per 100,000, and an average biochemical oxygen demand of 0.1 part per 100,000. The results of this experiment indicated that filter effluents of this composition could be used for processing coffee without conveying any serious taint to the liquor.

In another series of experiments, each of four different batches of coffee was divided into two portions; one portion was pulped, fermented and washed with filter effluent from the larger filter at Ruiru and the other portion was treated in the same way, but using river water instead of filter effluent. In the results given, the suffix A indicates that coffee was processed with filter effluent, and suffix B that it was processed with river water.

The order of preference of the samples of raw coffee was:—

1B, 2A, 2B, 3B, 1A, 4B, 3A, 4A,

suggesting that coffee processed with filter effluent was somewhat inferior in appearance to coffee processed with river water.

The order of preference of the liquors was:—

2A, 1A, 3A, 2B, 1B, 4B, 3B, 4A,

indicating that in three experiments out of four, coffee processed with filter effluent produced a somewhat better liquor than the same coffee processed with river water.

The filter effluents used in this series of experiments absorbed between 3.2 and 10 parts of oxygen per 100,000 from acid permanganate, and had values for biochemical oxygen demand between 4.9 and 13 parts per 100,000. The river water had an oxygen absorption of about 0.15 part per 100,000, and a biochemical oxygen demand of about 0.05 part per 100,000.

The coffee cherry available for the second series of experiments was not of particularly good quality, and it is possible that in processing coffee of the best quality it would be preferable to use fresh water rather than filter effluent, provided that the source of fresh water were not already contaminated by other discharges.

Summary

Mixed waste waters produced during processing of coffee are equivalent in polluting character to about 60,000 gallons of crude domestic sewage for each ton of clean coffee produced.

About 85 per cent of the total polluting matter is produced during pulping, and 15 per cent during washing of the fermented beans.

The most polluting liquids were, in order; tank effluent, first tank washings, and pulp water.

By rapid separation of pulp from conveying water, 40 per cent of the pollution contributed by pulp water can be avoided. This is equivalent to nearly 20 per cent of the total polluting matter from all sources.

Laboratory experiments indicate that the polluting character of the mixed waste waters, or of pulp water alone, can be greatly reduced by natural fermentation, but difficulties might arise in operating this method at a factory.

The biochemical oxygen demand of the mixed waste waters was reduced by up to 50 per cent by treatment with chemical coagulants, but it was concluded that addition of coagulants would not be a suitable means of treatment, owing to the close control required and difficulties involved in disposal of sludge.

Experiments suggest that the most satisfactory method of treatment would be by biological filtration. The installation required to reduce the total polluting character by 94 per cent, at a factory producing one ton of clean coffee per day, would cost about £1,850.

In deciding which means of treatment is to be adopted, consideration should be given to local conditions, such as the degree of dilution available in the river to which the effluent is discharged and the requirements of other riparian owners. In deciding what size of plant is required, reference should be made to the production of clean coffee at each factory over a period of several years.

Provided the effluent is of reasonably good quality, it seems unlikely that use of filter effluent for factory operations would have any harmful effects on the quality of the coffee.

Acknowledgments

This investigation formed part of the programme of the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research of Great Britain. It was made at the invitation of the Government of Kenya, who bore the cost of the work, and the programme of work was decided in consultation with the Water Pollution Research Committee of the Water Board of Kenya. This paper is published by permission of the Government of Kenya and of the Department of Scientific and Industrial Research.

Valuable assistance was given by the Public Works Department, Kenya, particularly by the Hydraulic Engineer and members of his staff who were responsible for the construction of the experimental plant, by the East African Industrial Research Board, which provided laboratory facilities and staff to assist in the work, and by Mr. C. D. Gee, Mr. N. R. Solly, and Mr. R. E. Rodseth who generously provided facilities for experimental work on the estates at Kiambu and Ruiru. Mrs. A. K. Ryland was responsible for much of the analytical work.

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FURTHER NOTES ON THE PROTECTION OF TIMBER AGAINST TERMITES

By W. Victor Harris, Senior Entomologist, Department of Agriculture, Uganda Protectorate

(*Received for publication on 6th January*, 1949)

In an earlier report (this Journal XIV, pp. 49–50; July, 1948) results were given of graveyard trials with formulations of D.D.T. and B.H.C. for the protection of timber against termite attack. Slabs of a susceptible local timber were protected for seventeen months by all 10 formulations employed, while only one of eight untreated slabs escaped damage.

On 30th January, 1948, the 80 treated slabs of *Mæsopsis* timber, together with eight new untreated controls, were randomized in a new graveyard site. Owing to unseasonally dry weather in March, the site was covered with a layer of wood shavings and watered at intervals in order to encourage the free movement of termites within the area. On 7th December, 1949, it was found that a number of slabs were rotting, so the trial was brought to a conclusion. The length of this exposure was 10 months, making a total of 27 months for the treated slabs. The results in the following table were obtained.

Treatment	Heavily Damaged	Light Attack	Undamaged
Untreated control ..	4	1	3
B.H.C.1%, miscibleoil	2	2	4
B.H.C. 5%, in dieseline	1	3	4
D.D.T. 5%, emulsion	1	1	6
D.D.T. 5%, in dieseline	1	0	7
D.D.T. 5%, in kerosene/cotton seed oil	1	0	7
D.D.T. 5%, emulsion	0	1	7
B.H.C. 1%, liquid concentrate	0	1	7
D.D.T. 5%, soluble oil	0	0	8
D.D.T. 5%	0	0	8
B.H.C. 5%, in kerosene/cotton seed oil	0	0	8

The damage was due to two termites, *Bellicositermes natalensis* and *Microtermes* sp. It was noticeable there was an absence of grading from light to heavy damage; most of the heavily damaged slabs were over three-quarters eaten away below ground level, while light attack consisted of slight superficial scraping.

Mulching the site with wood shavings had favoured the onset of fungus attack, and this did not appear to have been inhibited by the treatments. With a timber such as *Mæsopsis* a fungicide would require to be added to the formulation to provide complete protection.

In assessing the practical value of these trials, it must be borne in mind that treatments were restricted to dipping or to soaking for thirty minutes. An extension of time of soaking, with the inevitable consumption of more insecticide at an increased cost of treatment, would in all probability extend the length of life of the protective layer. Soaking for thirty minutes in five per cent D.D.T. in power kerosene has given satisfactory results with garden timber—stakes, plant labels, etc.—over a period of twelve months.

A NOTE ON THE NITRATE CONTENT OF SOIL UNDER PENNISETUM PURPUREUM

By G. ap Griffith, Department of Agriculture, Uganda

(*Received for publication on 31st December*, 1948)

Under Uganda conditions two important effects of the (*Pennisetum purpureum*) fallow are noted, firstly that the land newly opened from elephant grass must be left for several weeks before successful planting of a crop can be undertaken, and secondly that when the grass is grown in strips a marked adverse edge effect shows itself for several feet into the neighbouring crop.

In conjunction with soil nitrate investigations now being made at Kawanda Research Station, observations have been made on a strip of elephant grass which was due for opening and planting with the Spring rains of

1948. The strip was sampled weekly for eight weeks before ploughing and thereafter each week until the end of October.

The nitrate content under the standing crop of grass was of the order of 10 parts per million. At the same time in the neighbouring strip which had borne a cotton crop and which was now virtually a bare fallow, with only the dry stems of the cotton plants remaining, the nitrate content was of the order of 100 p.p.m.

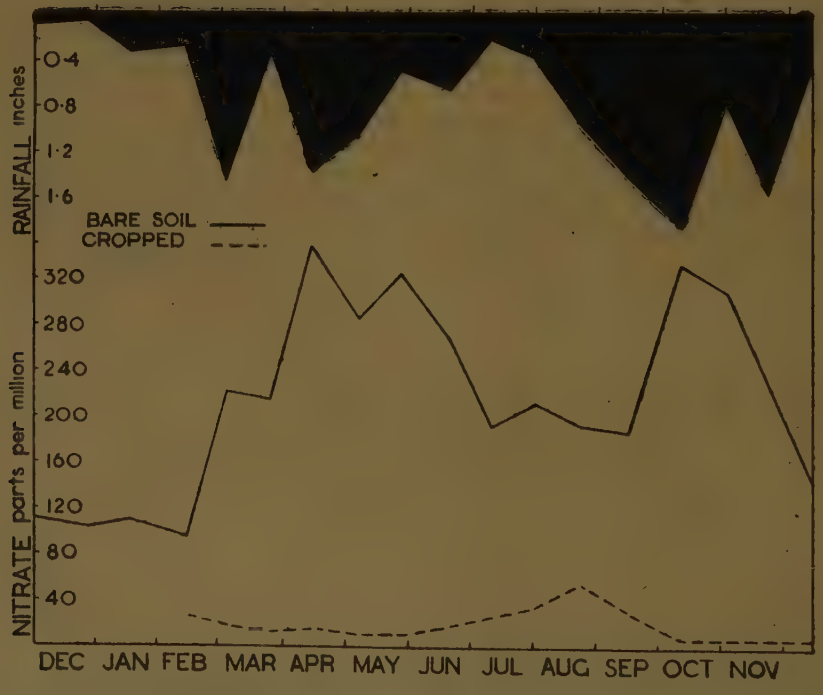
The grass was slashed on April 6th, the strip ploughed on April 20th, hand cultivated from May 4th to 13th, weeded again on May 31st, planted with cotton on June 10th, and weeded at (approximately) weekly intervals from then until the cotton had grown sufficiently to make a close ground cover about the end of August.

The nitrate content remained steady until about June 20th, (a week after the cotton had been planted) when it began to rise slowly to a peak of 50 p.p.m. on September 5th, after which it fell, rather more quickly than it had risen, to its original level of 10 p.p.m.

Observations on a bare fallow, conducted simultaneously with these, showed that nitrate accumulation began immediately on the onset of the rains in February and was going on actively throughout the period under review. By contrast on the newly opened land there was a time lag of over eight weeks before the processes leading to nitrate accumulation began to get under way. This agrees quite closely with the local empirical estimate of the time which should elapse before opening out fallow and planting the subsequent crop. At the same time nitrate accumulation did not attain anything approaching the magnitude of that on the bare fallow where figures over 400 p.p.m. were recorded. Two factors suggested as contributing to the lower nitrate accumulation are, firstly the increasing shading of the soil on the plot as the cotton grew, and secondly the consumption of nitrate by the weed growth and by the cotton crop itself.

The date on which nitrate content in the planted strip passed its maximum coincided approximately with the establishment of a complete ground cover by the cotton and coincided approximately also with the flowering peak of the cotton, a time when the cotton plant may be expected to begin its maximum demand on the soil nitrates.*

The results are summarized in the accompanying graph.



* R. C. Rainey, *Emp. Cott. Grow. Corp. Res. Memoirs No. 5*, 1948.

IS CUPRESSUS MACROCARPA POISONOUS TO FARM STOCK?

By H. S. Purchase, Chief Veterinary Research Officer, and W. P. Bruce, Research Laboratory, Veterinary Department, Kabete, Kenya

(*Received for publication on 17th December*, 1948)

In the *New Zealand Journal of Agriculture* there is a report by A. M. MacLeod [2] suggesting that the flowering heads of this plant caused seven abortions and two deaths in cows that had eaten this material. The other animals in the herd were listless and gave very little milk for some time after calving. On another farm he reports that six six-week-old calves gained access to some *C. macrocarpa* branches ready for burning and as a result of eating some of these, two of them lost all their condition, their eyes became sunken and they died. *The Kenya Weekly News* (1948) published an extract of this note.

A search in the literature available at Kabete was made and no recent record of stock-poisoning attributable to this plant could be found. However, in the *Journal of the Board of Agriculture* (October, 1905), two instances of possible poisoning of stock attributable to *Cupressus macrocarpa* and *C. nootkatensis* are recorded. The evidence was based on a report by Professor (Sir John) McFadyean, who found an inflamed condition of the fourth stomach and some pieces of *C. macrocarpa* at post-mortem examination, and in default of any other explanation it was suggested that this plant might have some poisonous properties. The report ends:—

> "The Board have no information as to the poisonous properties of these two species, nor can any record be found of any similar case which would tend to confirm the suspicion that they are poisonous to cattle."

In order to investigate this recent New Zealand claim that *C. macrocarpa* was poisonous to stock, two sheep were dosed each with 50 gm. of leaves suspended in water, at three-day intervals, on four occasions. These sheep remained healthy after being observed for over six weeks.

It would appear from this experiment that fresh leaves from the locally grown *C. macrocarpa* (the plants were not in flower), under the conditions and in the quantities above described, were harmless when fed to sheep. Experiments with cattle were therefore not undertaken, as past work on plant toxicity has shown that most plants harmful to cattle also have ill-effects on sheep.

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THE VALUE OF COLOSTRUM FOR THE NEW-BORN ANIMAL—A SHORT REVIEW

By E. G. White, Director, East African Veterinary Research Organization

(*Received for publication on 13th December*, 1948)

Animals develop immunity to bacterial and virus diseases in various ways. They may contract the disease naturally and subsequently recover, in which case a strong and lasting active immunity usually develops. A similar active immunity may be conferred by the use of biological products containing the living agents of the disease attenuated in various ways, or by killed disease-producing agents or modified products of their growth, such as toxin converted to harmless toxoid. In each case the animal is faced with the task of forming in its own tissue antibodies against the disease-producing agent.

An immunity of short duration can be conferred on an animal by giving it a dose of serum containing antibodies elaborated in the tissues of another animal: examples of diseases in which this method is used include rinderpest, tetanus, canine distemper and Rift Valley fever. Such passive immunity develops at once and lasts only a few weeks: active immunity, on the other hand, remains for months, years, or even for the duration of the life of the animal, depending on the disease concerned.

The newborn animal, protected *in utero* from infective agents unless they are sufficiently virulent to pass through the placenta (the membrane which separates dam and fœtus), is suddenly exposed at birth to a multitude of dangers from infections which may reach its tissues by ingestion, by inhalation or through the umbilicus. Two methods are provided by Nature to give the newborn animal immediate protection against such infections—antibodies are transmitted from dam to offspring (*a*) through the placenta and (*b*) in the colostrum or first milk.

In 1892 Ehrlich, pioneer worker on chemotherapy and immunity, found that antibodies against certain plant toxins were transmitted from mice to their offspring through the milk. Mice from immune mothers, transferred at birth to non-immune mothers developed no immunity, showing that the immunity was not congenital but was acquired after birth. This was confirmed by allowing the immune mothers to suckle the young of non-immune mothers: such young rapidly developed an immunity.

Little and Orcutt (1922) showed that agglutinins (antibodies) to *Brucella abortus* were transmitted from cow to calf in the colostrum and that the serum of the calf contained no agglutinins at birth. Agglutinins could be detected within half-an-hour of ingestion of colostrum and reached their maximum concentration after about five hours. This work demonstrated, therefore, that passive immunity in the calf, in the case of *Br. abortus*, was acquired through the colostrum and not through the placenta. In the case of calf fœtuses expelled prematurely from the uterus of cows in which active *Brucella* infection was present, the position was quite different. In such fœtuses the organism itself was present in the fœtal membranes, stomach and tissues, and agglutinins were detectable.

It has recently been shown (McDiarmid, 1946) that no agglutinins are detectable in the blood of newborn calves from cows vaccinated with *Brucella abortus*, strain 19, but that agglutinins appear one to three hours after ingestion of colostrum, reach a maximum after about 24 hours and disappear gradually over a period ranging from 2 to 18 weeks, depending in part on their original concentration.

Smith and Little (1922a and 1922b) showed the importance of colostrum in enabling the newborn calf to withstand calf scours. Of 10 calves given colostrum at birth, all survived. In contrast, 8 of 12 calves not given colostrum died and one was killed in a moribund condition. Feeding the serum of an adult bovine instead of colostrum afforded some protection but very large amounts of serum were required to provide the same protection as was given by the normal intake of colostrum. The intibody content of the serum of the dam may be only 1/40–1/20th that of the colostrum (Smith, 1930), hence the large amount of serum required to replace colostrum.

In a review of the causes of death among dairy calves, Lovell (1939) stressed the value of colostrum in preventing colibacillosis ("white scours"). This disease is caused by a disturbance of equilibrium between the calf and bacteria normally present in the bowel, in which the latter gain the upper hand. Improper feeding, lack of colostrum, and the

presence in a particular area of a specially virulent strain of *B. coli* were considered to be possible causes. The value of colostrum in preventing the disease was attributed to its intibody content and to its high content of vitamin A. Further evidence of the value of colostrum was obtained by Lovell and Hill (1940) from a survey of calf mortality in 335 dairy herds in England and Wales.

The antibodies present in high concentration in colostrum are associated with the protein lactoglobulin. This protein has recently been found to differ in certain respects (isoelectric point and electrophoretic mobility) from the serum globulin with which antibodies in the serum are associated. It seems, therefore, that the mammary gland attaches its own specific label to the immune globulin which it obtains from the maternal blood serum (Smith, 1948). This specially labelled lactoglobulin is accumulated in the udder during pregnancy and provides a rich source of antibodies for the newborn calf.

Within the first 24 hours after birth the intestine of the newborn animal is very permeable (Smith, 1930) and allows the large globulin molecules (mol. wt. 180,000) of the colostrum to be absorbed and converted into serum globulin. When the animal is a few days old such molecules can no longer be absorbed intact and have to be broken down to their constituent amino-acids by the digestive enzymes. For this reason, colostrum must be given within a few hours of birth if it is to provide antibodies for the newborn animal.

It should also be remembered that colostrum is of value in other respects besides providing antibodies. It acts as a laxative and helps in the elimination of the first stools. It is very rich in certain vitamins, particularly vitamin A, and it contains a very high concentration of valuable proteins which bring about a considerable rise in the serum proteins of the newborn animal and provide the "building stones" with which it can construct its own tissue proteins and manufacture its own antibodies.

The vitamin A content of the colostrum in the cow, goat and sow can be raised by feeding supplements rich in this vitamin during pregnancy (Wise *et al.* 1946: Thomas *et al.* 1947).

The transference of passive immunity to newborn calves through the colostrum may explain the difficulty experienced in immunizing young calves against rinderpest. Newborn calves from recovered or immunized cows presumably receive antibodies against the disease in the colostrum. In the case of other diseases there is evidence that although the level of these antibodies in the blood of the young animal falls rapidly, several months may elapse before they have completely disappeared. During this period such young animals may be refractory to immunization with attenuated or killed vaccines because of the partial protection provided by their passive immunity. In the same way, in an adult animal, the administration of hyperimmune serum may interfere with the reaction provoked by rinderpest goat virus. The difficulty of calfhood immunization for rinderpest may thus be associated with the residue of acquired passive immunity possessed by young calves. Experiments to test this hypothesis, on the lines of those carried out by Ehrlich, are required.

In this article we have so far dealt mainly with calves and with certain general problems of immunity of the newborn animal. Some consideration will now be given to other species.

Mason *et alia* (1930) showed that antitoxin is not transmitted through the placenta in the ewe, cow, bitch and mare. These authors were particularly concerned with the antitoxin of the lamb dysentery organism *Clostridium welchii*, Type B) and were able to show that this antitoxin was present in large amount in the colostrum of the ewe and was absorbed by the newborn lamb, provided it was given within a few hours after birth. In a four-day-old lamb no absorption of antitoxin occurred. As a result of this work a method of protecting lambs against lamb dysentery has been developed in which the ewes are vaccinated on two occasions during pregnancy with a formalized culture of the organism and the antitoxin is conveyed to the newborn lamb in the colostrum (Gaiger and Davies, 1947).

Earle (1935) showed that colostrum produces a marked rise in the protein content of the serum of newborn animals—foals, lambs, kids and piglets. With foals the rise in serum protein was proportional to the amount of colostrum globulin which was administered, an observation which has since been independently confirmed (Polson, 1943).

Foals born of dams immune to horse-sickness do not possess antibodies to this disease at birth but apparently acquire them with their first meal of colostrum (Alexander

and Mason, 1941). These antibodies are gradually lost over a period of about six months and during this time it is not possible to immunize such foals with horsesickness vaccine. The foal, like the calf and lamb, thus acquires immunity from its dam through the colostrum and not directly from the maternal blood.

At the Food and Agricultural Organization Rinderpest Conference held in Nairobi this year Dr. Alexander referred to an experiment in which two mares, one immune to horsesickness and the other susceptible, foaled on the same night. As soon as they were born the foals were switched over, the foal of the immune mare being put to the susceptible mare and vice versa. After a meal of colostrum the foals were returned to their own dams. The foal which suckled colostrum from the immune mare developed a passive immunity whereas the foal from the immune mare which obtained its colostrum from the susceptible mare did not develop an immunity. This experiment shows conclusively that colostrum is the vehicle which in the case of horsesickness transmits the passive immunity to the newborn foal. (Alexander, 1948).

There is evidence that in some species the colostrum is of less importance as a source of antibodies. In newborn babies, for instance, the main source of diphtheria antitoxin is probably the circulating antitoxin of the mother, transferred through the placenta.

One reason for the varying relative importance of the colostrum and the placenta as sources of antibodies in different animal species is possibly to be found in the structure of the placenta. Grosser (1933) classified the placenta according to the number of layers of cells which separate the maternal from the fœtal blood. In the horse and in ruminants there is a barrier, five or six cells in thickness, between the blood serum of the mother and that of the fœtus. In these species we have seen that antibodies are not present at birth, but are provided in the colostrum. In human beings there are only three layers of cells between maternal and fœtal blood sera. In babies one might, therefore, expect that antibodies would more readily pass from mother to fœtus. In the rabbit only one thin layer of cells separates maternal and fœtal blood. One would, therefore, expect a very easy transference of antibodies from mother to fœtus *in utero* in this species. Work on antibody transmission suggests that this is so.

In general, it does appear that the relative ease of transference of antibodies through the placenta may depend on the thickness of the cell barrier between fœtal and maternal circulation. It certainly is true that the newborn foal, pig and ruminant are almost entirely dependent on colostrum for antibodies at birth. It is likely, however, that the passage of antibodies into the fœtus depends on a variety of factors, of which the physical structure of the placenta, as revealed by histological study, is only one. The particular antibody concerned, its level in the maternal blood serum, the state of health of the fœtal membranes—these and other factors may also be concerned.

The work which has been cited represents only a small part of the evidence which has been accumulated during the last fifty years as to the importance of colostrum for the newborn animal. No effort should be spared to ensure that all newborn animals, of whatever species, are given an adequate supply of this most valuable product within 24 hours of birth. Colostrum possesses the combined properties of hyperimmune serum, vitamin concentrate, protein supplement and natural laxative. It can exert its beneficial effects only if given immediately after birth. Its protective value against infective diseases, vitamin deficiency and lack of body protein gives the newborn animal a good start in life until such time as it can manufacture its own antibodies and certain of its vitamins and until it can be provided with a complete mixed diet.

Recent work at the Ohio State University and Agricultural Experiment Station (Kaeser and Sutton, 1948) shows the value of utilizing all the colostrum available within a dairy herd by feeding any surplus to young valves. Observations were made on 76 calves divided into comparable groups at birth. Both groups received colostrum for the first three days after birth but calves in one group were also given surplus colostrum as a partial or complete replacement for whole milk. The animals in the latter group maintained higher blood levels of vitamin A and carotene, made more rapid weight gains, especially during the first six weeks, and showed a superior physical appearance. No scouring occurred when milk was replaced by colostrum. All the animals were bucket-fed from birth.

In those dairy herds in the United States in in which calves are bucket-fed from birth, only about 30 per cent of all the colostrum (udder secretion for the first three days after

calving) produced may find its way into calves, the remainder being used for other purposes or discarded. The authors calculate that the use for calf rearing of all surplus colostrum in the United States would represent an annual saving of 650,000,000 pounds of milk.

Whilst this problem of utilizing surplus colostrum arises only in the case of high-yielding cows it is none the less of interest to note that the Ohio experiments afford further evidence of its value in calf rearing.

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REVIEW

COLONIAL PRIMARY PRODUCTS COMMITTEE: SECOND REPORT, JANUARY, 1949.—*Colonial No.* 238, *published by H.M. Stationery Office, price Sh.* 1.

The terms of reference of this Committee are "To review, commodity by commodity, the possibility of increasing Colonial production, having regard on the one hand to the interests of the Colonial Empire and, on the other hand, to the prospective world needs and the desirability of increasing foreign exchange resources". In a previous report in January, 1948 (Colonial No. 217) the position was reviewed regarding animal products, rice, maize and millets, hemp, sisal and flax, jute and jute substitutes, coir, cotton, citrus fruits and juices, and fertilizers. This Second Report deals with a further selection—the vegetable oils and oil-seeds group, starch, fish and marine products, essential oils, timber, paper pulp tanning materials, and tobacco.

Farmers who contemplate experimenting with secondary crops will find useful advice and information in these Reports. For instance, the following quotation from the section on Essential Oils brings out two points which are of the utmost importance to the prospective producer "Existing producers of some oils have acquired a traditional skill and newcomers lacking this skill may find it difficult to make a success of production. It would be a mistake, however, to give great weight to this. Much expert knowledge is available in the United Kingdom and elsewhere and there should be no difficulty in obtaining access to it . . . It must be emphasized at the outset that even although the correct botanical vanity of plant is grown in a Colony, it does not follow that the oil obtained therefrom will have properties identical with those produced elsewhere".

A note of interest to sisal growers is given on page 45. "It was hoped that the use of sisal boles for paper pulp would provide a valuable by-product for the sisal industry in East Africa, but the resulting paper is a poor, weak, bulky, and very porous material. The fibres cannot be compared with straw or esparto and while it might have a use for wallboard or similar purposes it is useless as a raw material for the fine paper making".

The information is presented in a very condensed form, but there is no loss of clarity, and business men as well as agriculturists will find both this and the previous report valuable works of reference.

D.W.D.

PHORMIUM TENAX, NEW ZEALAND FLAX

By W. L. Jackson, Ellegirini Farm, Plateau, Kenya

(*Received for publication on 7th March*, 1949)

[*An article on Phormium fibre by Mr. Alfred Wigglesworth of Wigglesworth & Co. Ltd., London, appeared in volume* 12 *p.* 227 *of this Journal in* 1947 *which resulted in correspondence between Mr. Wigglesworth and Mr. Jackson which we published in Volume* 13 *p.* 55 *of the same year.*

Mr. Jackson now gives us his experience as as planter in developing this crop on a commercial scale in Kenya.—Ed.]

In certain categories this fibre is a competitor both of jute and of sisal. It is used for wool packs and hessians, and for rope and twine. Both the fibre and tow are used to the extent of about 20 per cent in making sisal bags for small grains, its function here being to close the mesh of the sisal. The fibre content of the leaf varies from 10 per cent to 16 per cent, depending on the variety. This contrasts with the 2½ per cent fibre content of sisal. Of this 10 per cent to 16 per cent the percentage of No. 1 fibre varies from one-third to two-thirds, depending on the variety and length of leaf, the balance being tow. Leaves as short as 18 inches can be decorticated, but the percentage of tow from such short leaf is very high. The minimum length of leaf for cutting is usually 3 feet; the longer the leaf, the better the results. The present prices of No. 1 fibre and No. 1 tow are about £65 and £35 a ton respectively, f.o.r. Ruiru.

The land for this crop should be very thoroughly cleaned. Our planting method is as follows:—We draw furrows with a single bottom mould board plough, 4 feet apart, along the general contours of the land. We then stretch a rope across the furrows, and plant at the intersections. When a line is finished we move the rope 4 feet along the furrows, and repeat. We consider this spacing best, as it permits cultivation both ways, with the minimum wastage of land. We use light Victory ploughs for cultivation, each with two oxen in a long yoke, and we keep them working all during the dry season. The amount of ground they will cover is surprising. Incessant cultivation must be practised in the first year, and a fair amount of hand work is necessary also, to keep down couch grass. In the next rains after planting, we sow lupins very thickly in the rows. This has several advantages, the chief being that it beats the couch grass and weeds. We have heretofore planted only suckers from old plants, but we are now turning over to plants raised from seed. The reason is that we have found that although suckers "take" very readily, at least 50 per cent of them grow in the form of a single fan; i.e. they do not stool. The seedlings, on the other hand, stool prolifically. We think that the extra time taken by the seedlings to attain a given length of leaf is compensated by the better stooling. Our seed beds are made as follows:—The bed is about 3 feet wide, of any length, and with a rather deep irrigation ditch on each side. The seed is broadcast on top of the bed, rather thickly, and very thinly covered with fine soil. The bed is then covered with about 4 inches of straw. This straw is watered occasionaly, but the main source of moisture is the irrigation furrows on either side, which are filled with water frequently, and then blocked off. The beds must not be allowed to dry out. When the bulk of the seed has germinated, which takes 6 to 10 weeks, the straw is removed, and a grass shelter, open at the sides, is built, 2 feet over the beds, and irrigation is continued as before.

Selective cutting is practised, and the first cutting can be taken in 2 to 2½ years from planting in the field. We have just started our factory, which consists of a standard stripper, a washing header with pump, an endless band for bearing off the fibre, and a brusher. The source of power is a John Deere Model "D" engine. The total cost, exclusive of power plant, is about £700, and its construction is well within the capabilities of any intelligent farmer. Water requirements are about 7,000 gallons an hour. The labour requirements for the factory alone will be about 20 natives. We think that with 4 ft. x 4 ft. planting, an estimate of one ton of fibre-plus-tow per acre per year from a plantation in full production—i.e. after the 4th year—is conservative. The capacity of one stripper is about 5 tons of leaf per day. We consider that 100 acres of Phormium would constitute an economic unit.

To conclude, these are some of the advantages pertaining to this crop:—

(1) Being a perennial, the first three years cover all the planting and cultivation costs.

(2) It is drought resistant.

(3) It can be cut at any time of the year, thus improving the labour enrol.

(4) *Phormium tenax* is an outstanding soil renovator.

(5) Once established, it will absolutely stop erosion.

(6) Closely planted, couch grass will make no headway.

(7) There is some reason to think that the leaf pulp can be used for cattle feed. At any rate, it is definitely non-poisonous; the pulp makes an excellent compost.

(8) It seems probable that, between East and South Africa, there will be an assured market for this fibre at remunerative prices.

REVIEW

FIELD CROP ABSTRACTS.—*Vol.* 1, *No.* 1, *January*, 1948, *Abstracts* 1–446, *published by the Commonwealth Bureau of Pastures and Field Crops, Penglais, Aberystwyth, Great Britain. Six issues per annum: annual subscription Sh.* 35.

This new abstracting journal has appeared as a result of a recommendation of the 1946 Review Conference of the Commonwealth Agricultural Bureaux, whereby the information centre formerly known as the Commonwealth Bureau of Pastures and Forage Crops became the Commonwealth Bureau of Pastures and Field Crops.

For the first time, abstracts of world literature on the cultivation and agricultural botany of all field crops which are grown in rotation are brought together under one cover. General sections on such subjects as land utilization and management, farming systems, machinery and equipment and the field control of weeds, diseases and pests, are followed by sections on cereals, legumes, oil and fibre crops, and root crops. Further sections deal with crop botany, physiology and biochemistry, environmental studies, taxonomy, and book reviews. In those sections of the journal containing abstracts on specific crops, each crop is dealt with under headings such as agronomy, crop geography, economics of production, adaptation and variety trials, etc.

The journal has six issues per year, appearing in January, March, May, July, September, and November, the first five containing author indexes, and the sixth being in the form of a comprehensive index, containing author, subject, crop and geographic indexes.

In the announcement which is published in the first number, the Editor says, "This first issue was published under many difficulties. In the first place, the definition of a 'field crop' presented a problem. Could potatoes, tobacco, and sugar-cane be regarded as such? In many countries all three are fitted into rotation systems, in which case they would be dealt with by this Bureau; on the other hand, sugar-cane and tobacco may be considered as plantation crops. Consequently, until problems such as this can be cleared up, there may be a certain amount of temporary overlap between this Bureau and the Bureaux of Horticulture and Plantation Crops, and of Plant Breeding and Genetics. Among other difficulties which faced us in embarking on the new venture were shortage of staff, lack of experience of the new subjects, and shortage of world literature covering all field crops. Fortunately these problems are already well in hand, and Field Crop Abstracts can now take its proper place among the other abstracting journals of the Commonwealth Agricultural Bureaux".

This journal will be welcomed by Agricultural Officers who wish to keep up to date with the advances in land usage and agricultural practice. Although it is an abstract journal and not a digest of recent information, the abstracts give the salient points of papers, and sufficient information is given to allow readers to follow the trend of current investigational work.

Farmers, who usually require detailed information on certain specific lines, may find the abstracts too condensed, but the following (Abstract No. 84) shows that even a very short abstract may give useful information: "The effects of a heavier seed rate and closer spacing on *Triticum vulgare* [wheat] were studied on dry and irrigated land. Significantly higher yields of both grain and straw were obtained by sowing 100 lb. of seed per acre and by using a 6-in. spacing between the rows".

Most specialist workers in agricultural science will find this a very useful journal, since it covers a wide range of subjects and includes abstracts from journals which are not found in the average scientific library.

D.W.D.

FIELD TRIALS WITH PHENOTHIAZINE (P.T.Z.) GIVEN AS A LICK TO SHEEP

By Barbara L. Duthy, Zoologist, Veterinary Research Laboratories, Kabete, Kenya

(*Received for publication on 4th March*, 1949)

The object of the experiment was the practical one of discovering whether P.T.Z. could be of use to the Kenya farmer in the control of sheep worms when mixed in a salt lick. The problem of controlling nematode infections in sheep in Kenya differs from that in more temperate zones in that there is a high concentration of larvæ on the pastures all the year round, there being no winter to reduce their numbers noticeably. The dry season does to some extent act in the same way as winter but even in the dry season, and especially on any damp ground, heavy infestations of worms may be picked up by sheep, and it is a regular practice on most farms to dose the sheep once a month all the year round. The other difference in this country is the amount of salt taken by sheep, which is much higher than in other countries, and it was therefore thought that a much lower concentration of P.T.Z. in the lick than that used by English and American workers, i.e. between 1:9 and 1:15, would be sufficient to control the worms. The experiment was carried out on a large farm and the normal farming practice was not interfered with except that the sheep were weighed once a month, and those on P.T.Z. did not receive the usual worm doses in most of the experiments. As it was impossible to make egg counts during the experiments or to kill many of the sheep for worm counts the results had to be guaged almost entirely from clinical signs and the weights of the sheep. To eliminate variable factors (as far as possible) the comparable flocks of sheep were grazed on the same type of pastures throughout each experiment.

The farm on which this experiment was carried out is very large, comprising three areas, Waterloo, Kinangop and Longonot. About 22,000 sheep are run on these areas and they are frequently moved from one part to another. All sheep are dipped and sheared on the Waterloo area. Waterloo and Longonot are both on the floor of the Rift Valley at about 6,000 ft. above sea level and have an average rainfall of a little over 20 inches a year. They are areas of dry open grassland dotted with *Acokanthera* trees and a few thorn trees (*Acacia* spp.), with patches of Ol'leleshwa (*Tarchonanthus camphoratus*). The grass is mainly star grass (*Cynodon plectostachyum*). On the other hand the Kinangop Plateau is open, seasonally waterlogged grassland, 7,000 to 8,000 ft. above sea level, with a rainfall of from 40 to 50 inches a year. There are almost no trees here and the pasture is frequently dominated by coarse *Pennisetum schimperi* and *Eleusine jægeri* interspersed with finer grasses, amongst which *Andropogon chrysostachyus* is prominent in many parts. Numerous other species of grasses occur and in localized areas Red Oat grass (*Themeda triandra*) is an important constituent of the herbage.

The object of the first experiment was to see whether lambs regularly dosed with wireworm remedy and also receiving P.T.Z. in the salt lick would have fewer worms and therefore be more healthy than those dosed with wireworm remedy alone.

This was started in February 1945 when a flock of twin lambs on Waterloo were divided into two comparable halves consisting of 55 lambs in each half. Both halves of the flock received wireworm remedy regularly and they were both given salt lick, but one half had P.T.Z. in their lick at the rate of 1:200 parts by weight. The lambs were later moved to the Kinangop.

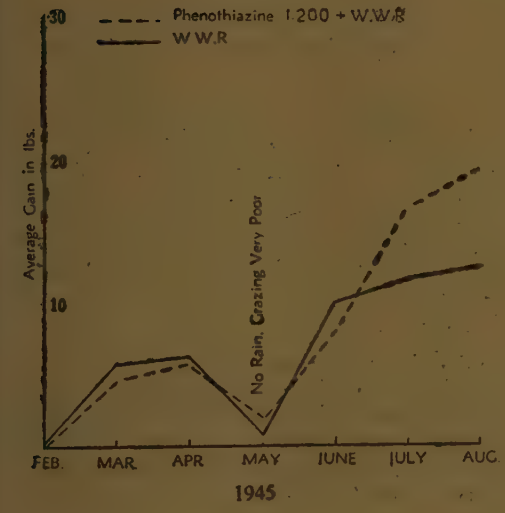
The wireworm remedy used was that originally compounded by Veglia (1918) and consists of four parts copper sulphate, partly dehydrated, and one part sodium arsenite.

The beginning of 1945 was very dry, and during April there was very little grazing so that all the sheep had lost weight by May. It rained in May and the grazing was good from then onwards. As will be seen from the table and graph the lambs receiving P.T.Z. showed little difference from the lambs without P.T.Z. in the initial months of the experiment, but the former picked up more steadily after the drought had broken and continued to do better until the experiment was discontinued in August.

TABLE I

Month	P.T.Z. 1:200 in Lick and Regular Dosing with W.W.R.		Dosed with W.W.R. only and Salt Lick Available	
	Average Weight	Av. Gain or Loss	Average Weight	Av. Gain or Loss
	Lb.	*Lb.*	*Lb.*	*Lb.*
Feb. ..	36·2	—	38·8	—
March	41	+4·8	44·9	+6·1
April	42	+1·0	45·1	+0·2
May ..	38	—4·0	39·2	—5·9
June ..	44·44	+6·44	48·9	+9·7
July ..	52·94	+8·50	50·5	+1·6
August	55·28	+2·34	51·5	+1·0

GRAPH I



Conclusions

P.T.Z. at the rate of 1:200 in the lick appeared to be of benefit to lambs that were already being dosed with wireworm remedy.

A second experiment was started in December 1945 on two flocks at Waterloo farm as the results from the first experiment were promising. Both flocks were lambs of maiden ewes born at approximately the same time.

The object of this trial was to compare the effects of P.T.Z. (1:200) with regular dosing with W.W.R. Both flocks received salt as a lick. In both flocks the lambs were about a month old when the experiment was started. The flock receiving P.T.Z. contained 391 lambs and the other 393 lambs.

As will be seen from the table and graphs the P.T.Z. lambs did better than the controls until they were weaned in May, when the flock receiving P.T.Z. still contained 376 lambs and the other flock contained 374. They were marked and then herded with two other flocks of weaners so that each flock now contained about 1,000 sheep but only the marked ones were weighed. In July two months after weaning, the flock receiving P.T.Z. looked definitely wormy and one animal from each flock taken at random, was slaughtered and examined for worms with the following results:—

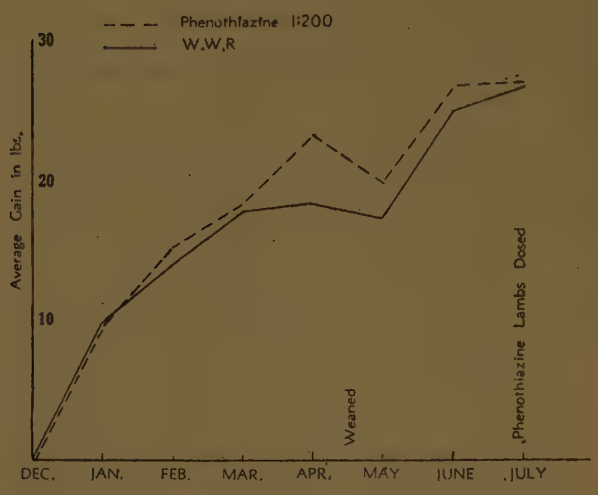
	Weaner from P.T.Z. Flock	Weaner from W.W.R. Flock
Hæmonchus contortus	255	7
Bunostomun trigonocephalum ..	10	—
Monezia expansa	3	4
Œsophagostomun columbianum	11	11

It was then decided to dose all the sheep with wireworm remedy and to discontinue the experiment.

TABLE II

Month	P.T.Z. in Salt Lick			Wireworm Remedy and Access to Salt Lick		
	Number of Lambs Weighed	Average Weight	Average Gain or Loss	Number of Lambs Weighed	Average Weight	Average Gain or Loss
		Lb.	*Lb.*		*Lb.*	*Lb.*
December ..	391	19·65	—	393	21·03	—
January ..	387	29·11	+9·46	385	31·00	+9·97
February ..	384	35·84	+6·73	381	35·33	+4·33
March	382	38·08	+2·24	379	39·22	+3·90
April	379	42·90	+4·82	376	39·60	+0·38
	Moved to Longonot and weaned.					
May	376	39·37	—3·53	374	38·17	—1·43
June	369	46·30	+6·93	366	46·11	+7·93
July	288	46·98	+0·68	365	47·45	+1·34
	Moved back to Waterloo.					

GRAPH II



Conclusion

The results of this experiment showed fairly conclusively that P.T.Z. at the rate of 1:200 in a salt lick was inadequate (as compared to the regular dosing with W.W.R.) in combating worm infestation under the conditions met with on the floor of the Rift Valley.

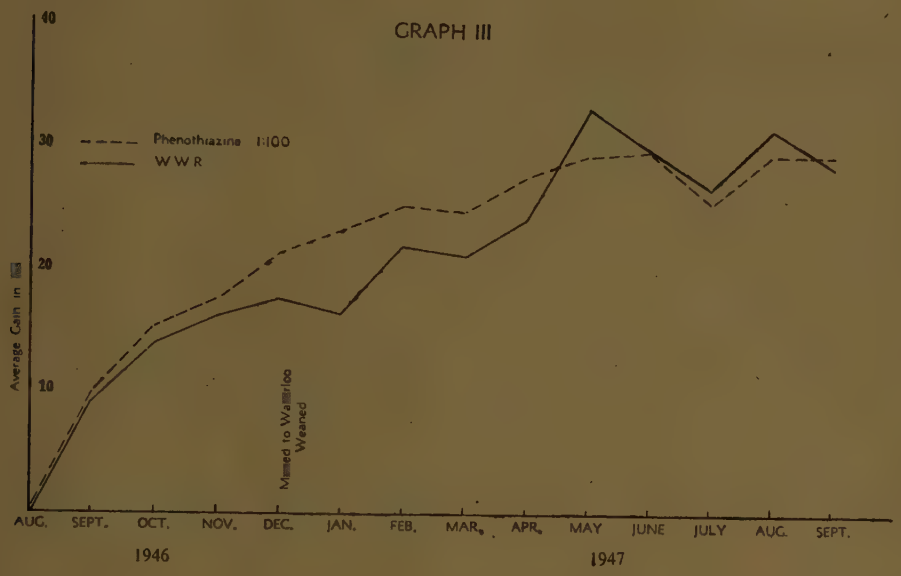
A third experiment was started in August, 1946, to see whether P.T.Z. at the higher rate of 1:100 would be effective in keeping the worm burden in lambs under control. Two flocks of lambs born on the Kinangop from maiden ewes were used in this experiment. One of these flocks was given the ordinary salt lick and dosed regularly with wireworm remedy while the other received P.T.Z. at the rate of 1:100 in the salt lick and was not dosed with wireworm remedy. All through this experiment the sheep receiving P.T.Z. appeared clinically healthy and at no time did they receive any worm remedy other than P.T.Z. in the lick. The year was exceptionally wet and hence a severe test of the treatment. The sheep receiving P.T.Z. lick did definitely thrive better during the early part of the experiment but after March they did no more than equal those dosed with W.W.R. This may be partly due to the fact that they were then moved down to Waterloo where sheep do not take as much lick as they do on the Kinangop. It was intended that the ewes of this flock should continue receiving P.T.Z. lick but the supplies of this were exhausted and in September, 1947, the experiment was terminated.

Conclusion

P.T.Z. in the lick at the rate of 1:100 was in this trial as successful as wireworm remedy in combating the worm infestation and showed especially good results in the early stages when the lambs were on the wetter Kinangop grazings and consumed more salt lick.

TABLE III

Month	P.T.Z. (1:100) in Salt Lick			Wireworm Remedy and Access to Salt Lick		
	Number of Lambs Weighed	Average Weight	Average Gain or Loss	Number of Lambs Weighed	Average Weight	Average Gain or Loss
		Lb.	*Lb.*		*Lb.*	*Lb.*
August ..	398	31·01	—	398	32·87	—
September ..	398	40·35	+9·34	395	42·03	+9·16
October ..	397	45·96	+5·61	389	46·60	+4·57
November ..	397	48·72	+2·76	391	49·10	+2·50
December ..	397	52·05	+3·33	375	50·56	+1·46
	Moved to Waterloo. Shorn and Dipped. Weaned.					
	Average Wool—2·8 lb.				Average Wool—2·5 lb.	
January ..	392	50·44	—1·61	339	46·84	—3·72
February ..	380	52·23	+1·79	329	52·38	+5·54
March	365	51·82	—0·41	300	51·51	—0·87
April	360	54·95	+3·13	281	54·56	+3·05
May	345	60·78	+5·83	219	64·24	+9·68
June	345	61·28	+0·50	252	60·10	—4·14
	Shorn and Dipped. Wool—3 lb.					
July	331	56·68	—4·60	273	57·27	—2·83
August ..	316	60·81	+4·13	266	62·80	+5·53
September ..	316	60·94	+0·13	252	58·74	+4·06



The object of the fourth experiment was to compare the effects of P.T.Z. alone at two levels and W.W.R. dosing augmented by P.T.Z. at a low level.

This was instigated in January, 1947, on three flocks of lambs on Waterloo Farm, one flock receiving P.T.Z. at the rate of 1:200 together with wireworm remedy dosing, the second received only P.T.Z. at the rate of 1:100 and the third P.T.Z. 1:50 in the salt lick. Neither of these last two flocks received wireworm remedy.

The experiment was started at Waterloo but in March the flocks were moved to Longonot. In April the lambs were weaned and in June they were moved back to Waterloo to be shorn and dipped.

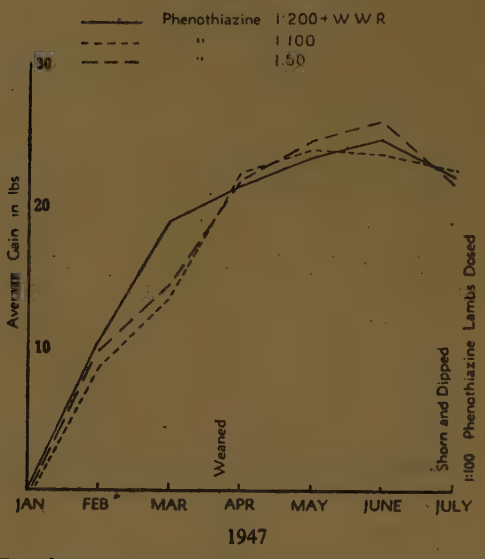
Up till July there was very little to choose between the three flocks, none of them throve very well as it was a very wet year and the lambs were poor from the beginning. In July the flock on P.T.Z. (1:100) were scouring and appeared clinically wormy and a dead lamb that was examined had many hundreds of *Hæmonchus contortus* so this flock was immediately dosed with wireworm remedy. On the other hand the flock that was receiving P.T.Z. at the rate of 1:50 appeared healthy and did reasonably well throughout the season. This experiment also had to be terminated in September, 1947, due to shortage of P.T.Z.

TABLE IV

Month	P.T.Z. (1:200) in Lick and Dosing with W.W.R.			P.T.Z. (1:100) in Lick			P.T.Z. (1:50) in Lick		
	Number of Lambs Weighed	Average Weight	Average Gain or Loss	Number of Lambs Weighed	Average Weight	Average Gain or Loss	Number of Lambs Weighed	Average Weight	Average Gain or Loss
		Lb.	*Lb.*		*Lb.*	*Lb.*		*Lb.*	*Lb.*
January	365	20·27	—	385	26·01	—	396	31·96	—
February ..	352	30·81	+10·54	382	35·74	+9·73	389	41·71	+9·75
March	343	39·29	+8·48	383	40·61	+4·87	384	46·90	+5·19
April	335	42·36	+3·07	382	48·59	+7·98	383	54·15	+7·25
May	329	44·70	+2·34	381	50·32	+1·73	380	56·04	+1·89
June	322	46·92	+2·22	376	50·58	+0·26	376	58·11	+2·07
				Moved to Waterloo—Shorn and Dipped.					
July	309	44·07	—2·85	347	47·04	—3·54	371	53·56	—4·55

The loss of weight is attributed in the main to shearing.

GRAPH IV



Conclusions

From these results P.T.Z. in the lick at the rate of 1:50 would appear to control worms in lambs and weaners even in a very wet year; while at the rate of 1:100 in the lick P.T.Z. failed to control worms in weaners grazing in the Rift Valley where the consumption of salt is reduced, although it had been successful at the higher elevation of the Kinangop where sheep take more salt. P.T.Z. at the rate of 1:200 with regular dosing with wireworm remedy gave results comparable to P.T.Z. alone at 1:50.

Peterson, Kammlade and Webb (1944) used P.T.Z. licks at the rate of 1:14 and found that 18 sheep consumed one lb. of this a week. Utilizing the figures of the total amount of lick consumed over several weeks and dividing this by the number of sheep fed, it was found that on the Kinangop 5 sheep consumed one lb. of lick in a week. Therefore the intake of P.T.Z. taken as a 1:50 lick by the Kinangop sheep is about 0.12 grams per day and is commensurate with that recorded by the above authors, but is about half as much as was taken by lambs in Great Britain in experiments carried out by Harbour, Morgan, Sloan and Rayski (1946) with 1:14 and 1:9 concentrations when the intake of P.T.Z. was at the rate of about 0.25 grams per day from both licks—and a great deal less than Britton and Miller (1944) used giving a 1:10 mixture when the sheep consumed up to 30 grams a month.

On Waterloo, however, the sheep only consume about two-thirds the amount of lick as compared to when they are grazing on the Kinangop.

A possible explanation why young lambs respond better to P.T.Z. in the lick than weaners may be that they consume larger amounts of lick in comparison with their size.

Discussion

As has been already stated the helminth problem in Kenya, an equatorial country without climatic extremes differs markedly from that in temperate regions which experience a regular winter. The experiments described in this paper are "pilot" experiments carried out on an established sheep farm with the minimum of disturbance to the normal routine of sheep rearing. They have shown a real need to investigate further the use of P.T.Z. in Kenya. The following information is required before a true understanding of the value of P.T.Z. in licks can be obtained. How much lick is taken by sheep at pasture? Does this vary significantly between the dry and wet seasons? There is unequivocal evidence that sheep on the Kinangop consume more salt than when the same sheep are at Waterloo which is 1 to 2,000 feet lower. Is this due entirely to the difference in altitude or is it linked with the nature of the soil and resultant vegetation which the soil supports?

When lambs on one large farm with contiguous differing areas reveal such variable responses to P.T.Z. how much more will the results of using this drug vary when applied over the whole of Kenya? These are some of the problems that must now be investigated to assess the potential value of P.T.Z. in licks as an anti-helminthic weapon for use in sheep on range.

I wish to acknowledge with gratitude the co-operation received during the experiments from Mr. D. Begg and Mr. D. Hazelden who were in charge of the sheep; to thank Dr. H. S. Purchase for help in preparing the script and Mr. E. Beaumont, D.V.S., Kenya, for permission to publish this article.

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A SIMPLE POT CULTURE TECHNIQUE FOR STUDYING THE RELATIVE "EARLY AVAILABILITY" OF PHOSPHATIC FERTILIZERS WHEN ADDED TO DIFFERENT SOIL TYPES*

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It will be appreciated that much progress has still to be made in working out more trustworthy laboratory methods for estimating the true available phosphate status of virgin and manured soils. This is especially the case with leached, highly coloured, lateritic tropical soils which hold phosphate against acid extractions but which liberate large amounts of anion phosphate with weak alkali. With most temperate soils, the standard methods, involving the use of weak mineral or organic acids, are useful when the interpretation of the range of values obtained for particular soil types can be correlated with field response, and when the reaction values of the particular soils are known. In the case of lateritic soils, the range of values obtained by static methods of acid extraction are exceedingly low, and are very close for soils which are known to vary greatly in their true available phosphate status. Thus, the available phosphoric oxide indicated by the citric-solubility method will only vary from, say, 0.0010 per cent to 0.0015 per cent for soils with known different responses to added phosphate and, indeed, the actual need for phosphate can often be better judged by the base status, reaction value, organic matter content and structure of individual soil samples within a soil type. However, when dynamic, and not static, methods of acid extraction are used, the values obtained show no marked falling off of the amounts of P_2O_5 liberated in successive extractions and the summation of these do give a fair indication of phosphate availability throughout the growing season, as long as it is certain that no unabsorbed, recently applied phosphate is present. When these lateritic soils are treated with weak, cold alkali, about twenty times as much phosphate, comprising about one-third of the total P_2O_5 content of the soil is very readily displaced, but again, the correct interpretation of the results in terms of the true need for phosphate is difficult.

On the other hand, field trials to study phosphate requirements and the relative availability of different classes of phosphatic fertilizers applied in different ways, though they give the best approximation, have to be statistically sound (and therefore elaborate) and have to be repeated for different soil conditions. The main purpose of this paper is to give an account of a fairly rapid, intermediate method that makes use of the marked ability of the roots of cereal seedlings to extract phosphate from untreated soils and from soils which have received certain known treatments under standard conditions. This paper also gives a selection of some of the results obtained and indicates the scope of investigational work that can be undertaken by the pot culture technique described.

The method has been developed at the Scott Agricultural Laboratories since 1935, certain alterations in the technique being made from time to time when found advisable. The method has special application to conditions in laboratories employing African Laboratory Assistants as, with supervision, this staff is able to do most of the laboratory work involved. The method was first used to note the relative intake of P_2O_5 from representative samples of some of the main soil types commonly used for the growing of cereals. At that time there had been little phosphatic manuring of cereals in the Kenya Highlands, and there was not much sound information on the need for phosphates. The results were correlated as far as possible with the normal yields of grain, it being assumed that soils which produced very good yields did not require phosphates, and also with the limited information about certain soil types which were known, in a general way, to give better yields following phosphatic manuring. It was estimated that seedlings which contained less phosphates than the original seed used, under the standard conditions of washing and analysis, were in great need of phosphates and that those with net gains of 0 to 4 mgms. under the same standard conditions of growth needed added phosphates.

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When normal field dressings of 40 and 50 parts per million P_2O_5 (4 mgms. and 5 mgms. per 100 grams soil) were added in the form of superphosphate to the phosphate-deficient soils, the intake was increased by about 1 mgm. only, the recovery with different soils varying between 17 per cent and 22 per cent. This suggested that much larger dressings were necessary for the study of the relative 'early availability' of different fertilizers and later 1,000 p.p.m. of total P_2O_5 (100 mgms. per 100 grams of soil) were added. The method was found to be very useful in noting the relative extra intake of P_2O_5 that took place when different classes of phosphatic fertilizers were added to different soil types. A special study has been made of the use of 'water-solube', as compared with 'water-insoluble' but highly 'citric-soluble' phosphates (e.g. sodaphosphate) when these are added to soils which are known to fix the superphosphate class of phosphate very readily. The very high extra intake of phosphate, amounting up to 50 mgms. per 100 seedlings grown in 200 grams of soil, and the good agreement between triplicate pots under the same treatment, showed that the method could be used to show up small differences in 'early availability', resulting from minor differences in treatment, such as using different mineral phosphates, using different fineness of grinding, and the effectiveness of different methods of placing and the timing of phosphate applications. More recently, work has been done on the relative intake when different classes of phosphatic fertilizers are dressed on to the seed as compared with placing in the soil.

Certain Essentials of the Pot Culture Technique Used

At first, a modification of the Neubauer method was used, as described in Technical Communication No. 25 published by the Commonwealth Bureau of Soil Science in 1932. As it was found that portions of the roots became matted on the base of the container and were thus ineffective in absorbing nutrients, the soil was made deeper both by using narrower containers and by doubling the amounts of dry soil and fertilizer used, an allowance being made for the moisture content of the soil. Nearly all cereal soils of the Colony are loamy or lighter in texture, and with such soils it was found that there was no need to add sand. Instead, adequate aeration and drainage were secured by puffing up the soil itself by adding the necessary amount of water to the soil passing through a 2 mm. sieve and then teasing this and sieving the damp mixture before transferring it to the container. By this method, the apparent density of the dry soil can be decreased to between 0.75 and 0.80, thus giving a very high pore space which ensures good aeration. It was found necessary to have the lots of 100 seeds (of the same weight) within a series, as less plump seed contributed relatively more initial supplies of phosphates. Thus, in the case of wheat, picked larger grains contained 0.631 per cent P_2O_5 whereas the smaller seed contained 0.739 per cent. Furthermore, the lots of 100 seeds, usually 12 or 15 in the same series, had to be adjusted to the same standard weight at the same time early in the day owing to rapid changes in hydroscopic moisture content. Different sources of rye and wheat of proved high germination have been used from time to time, and there has been no need to treat the seed with fungicidal solution. Germination, which takes three or four days, was carried out indoors, where the temperature does not vary much from 20°C., and the containers were then placed in plaster of Paris moulds holding 12 pots and placed out of doors during daylight and brought in to an open covered shade overnight and during rain. The moisture content of the soil was not maintained at a constant level, but water was added at intervals by means of a pipette, when the seedlings grown in 6 cms. of soil showed the first symptoms of drought. The seedlings, which made healthy growth under these conditions, attained a height of 20 to 27 cms. in the 14 days following germination. They were harvested by being washed free of soil by a standard method and there has been no need to cut off each shoot from the mass of roots. Seedlings of normal growth were separated from any with stunted growth, counted and analysed for their total P_2O_5 content by a particular routine volumetric method which has been found to give very uniform results. In trials involving the dressing of the seed with phosphatic fertilizers, it was found that no form of washing could remove all the phosphate residues from the seed coat, and in such trials, the phosphate contained in the shoots and roots only has been used for comparative purposes. Most of the extra phosphate is contained in the shoot.

With the use of sulphuric acid in the digestion, and with the standard method of precipitation and washing of the precipitate used, it has been found necessary to use a determined low factor of 1 ml. $\frac{N}{10}$ NaOH = 0.00029 gr.

TABLE I

	Number of Normal Seedlings Analysed and Actual P_2O_5 Content in mgms.		Proportional Content in 100 Seedlings	P_2O_5 Supplied in 100 Seeds	Intake from Soil in mgms.
200 mgms. total P_2O_5 added to 200 grams of soil—Control Seedlings	95	11·36	11·99	12·44	—0·45
	98	11·64	11·87	12·44	—0·57
	99	11·67	11·79	12·45	—0·66
Mean	—	—	11·88	—	—0·56
				Extra Intake, i.e. less 11·88 mgms. P_2O_5 in 100 Control Seedlings	Per Cent Recovery of Added Phosphate
Low-grade sodaphosphate 25% total, 13·9% citric-soluble P_2O_5	99	37·94	38·32	26·44	13·22
	95	37·51	39·48	27·60	13·80
	94	36·04	38·34	26·46	13·23
Mean	—	—	—	—	13·4%
High-grade sodaphosphate, 23·6% total, 22·8% citric-soluble P_2O_5	98	59·42	60·63	48·75	24·37
	98	57·25	58·42	46·54	23·27
	96	56·13	58·47	46·59	23·30
Mean	—	—	—	—	23·6%
Superphosphate 20·2% total P_2O_5	96	52·37	54·55	42·67	21·33
	98	55·47	56·60	44·72	22·36
	97	54·80	56·50	44·62	22·31
Mean	—	—	—	—	22·0%

P_2O_5. This rapid method gives excellent agreement for replicate analyses. It was found necessary to have all pot culture treatments done in triplicate to give a fair mean value of phosphate intake as compared with blanks. In investigational work, the blanks have been seedlings grown in the same, untreated soil and not in acid-treated sand, as it has been noted that the differences between the total phosphate in the original seed and that recovered in the control seedlings—usually a loss—varied with the soils used.

Details of the pot culture technique at present in use with notes on the setting up of the pots, their maintenance, the harvesting of the seedlings and their analyses, are given in the form of an Appendix.

Some Examples of the Use of the Pot Culture Technique in Investigational Work

Over a score of different series of pot culture trials, arranged to give particular information, have been carried out. The results of some of these are given in detail to show the range of values obtained and how the results are worked out.

Example 1.—The 'early availability' of low and high grade sodaphosphate was compared with that of superphosphate using rye grown in the Thomsons loam to which 1,000 p.p.m. total P_2O_5 (200 mgms. per 200 grams soil)had been added.

The above example illustrates how very good agreement can be obtained for triplicates of the same treatment. When large numbers of pot culture estimations are made to note the recovery of added phosphates, there will be a difference of 1 to 2 mgms. in the blank or seedling control estimation, and up to 4 mgms., and occasionally a still larger difference, for the triplicate tests when large amounts of P_2O_5 of the order of 40 to 50 mgms. are recovered from the added fertilizer. In such cases any 'outside' figure is taken to be due to some abnormal failure of phosphate intake or to some fault in the preparation and analysis of the plant tissues. In such cases, the mean of two close samples only is taken. The results given in the above Table show that there was a loss of about 0.5 mgms. only in the blank, suggesting a soil needing phosphates. It will be noted that the control rye seedlings con-

TABLE II

	Number of Normal Seedlings Analysed and actual P_2O_5 Content in mgms.		Proportional Content in 100 Seedlings	P_2O_5 Supplied in 100 Seeds	Intake from Soil
200 mgms. total P_2O_5 added to 200 grams of soil— Control Seedlings ..	95	26·14	27·52	28·04	—0·52
	98	28·30	28·88	28·04	+0·84
	96	27·02	28·15	28·04	—0·11
Mean	—	—	28·18	—	—
				Net Intake, i.e. less 28·18 mgms. P_2O_5 in 100 Control Seedlings	Per cent Recovery of Added Phosphate
Applied as Triple supers..	94	50·00	53·24	25·06	12·5
	96	54·98	57·27	29·09	14·5
	94	52·78	56·15	27·97	14·0
Mean	—	—	—	—	13·7%
Applied as ammonium phosphate	99	62·16	62·79	34·61	17·3
	95	59·16	61·22	33·04	16·5
	95	59·74	62·88	34·70	17·3
Mean	—	—	—	—	17·0%
Applied as sodium phosphate	96	73·76	76·73	48·55	24·3
	97	71·10	73·30	45·12	22·6
	94	69·48	73·91	45·73	22·9
Mean	—	—	—	—	23·3%

tained about 12 mgms. P_2O_5, whereas in the case of those grown in treated soils, the seedlings contained 40 to 60 mgms of total P_2O_5. The extra intake is taken to be the difference between the total P_2O_5 content of 100 seedlings grown in treated soil and that in 100 control seedlings. The recovery values from the phosphate applications indicate that the high grade sodaphosphate with 22.8 per cent of citric-soluble P_2O_5 is much more 'early available' than the lower grade material with 13.9 per cent only of citric-soluble P_2O_5. The high grade sodaphosphate gave a 'root-soluble' value per unit of total P_2O_5 of the same order as for superphosphate in the case of this particular soil type. As 200 mgms. of total P_2O_5 were added to 200 grams of soil, the percentage recovery values given in the last column are half of the actual intake in mgms. of P_2O_5.

Example II.—Another example of the use of this pot culture method in investigational work, which is given in detail, deals with the varying 'early availability' of the PO_4 anions when these are applied as triple superphosphate, ammonium phosphate and sodium phosphate. In this trial, wheat seedlings were grown on the Kipkabus loam which readily fixes added phosphates.

The phosphate recovery for control seedlings grown in the soil without treatment was similar to that contained in the seed used. It will be noted that there was a maximum difference of 1.4 mgms. between the extreme values obtained. The recovery values from triple superphosphates are lower than usual, even for a soil which readily fixes added water-soluble phosphates. The recovery is higher with ammonium phosphate and still higher with sodium phosphate. These initial results suggest the need for further pot culture and field work on the influence of the cation on phosphate fixation in the case of these extensive tropical lateritic soils. As these soils respond to sulphate of ammonia, the use of the concentrated fertilizers based on ammonium phosphate, may be specially suitable.

Example III.—A third example given in detail shows the special technique that is required when the pot culture method is used in investigational work involving the dressing

of phosphates on to the seed. In this trial, using wheat grown in the Kikuyu loam, the phosphate intake from sodaphosphate and triplesuperphosphate dressed on to the seed is compared with the intake following the placement of the same quantity of both fertilizers. The dressing was done by wetting the seed with a solution of casein glue and then, after an interval, dusting and mixing with weighed amounts of finely ground fertilizer. When any phosphate was dressed on to the seed, and the shoot root and seed portions of the resulting seedlings were analysed, it had been found that no reasonable amount of washing could remove all phosphate adhering to or within the seed coat; the phosphate contained or held in the seed portion only of seedlings produced from dressed seed was variable and often very much higher than in the case of growth following fertilizer placement. Thus, in comparative intake trials of this kind, it was necessary to discard the seed portion and to base the results on the amounts of phosphates present in the cut off shoots and roots only. After removal from the soil and washing by the standard method, intake in these portions of the plants only was compared with that in similar portions of the control seedlings. This series illustrates greater than usual differences in the number of normal seedlings produced due mainly to fertilizer damage, more especially in the case of triple supers dressed on to the seed, and partly due to a less uniform growth of the seedlings, resulting from slight deviations from the normal method of ensuring adequate aeration of the soil.

In other tests, using triple superphosphate mixed with the soil, 100 seedlings contained 51 mgms. P_2O_5, 75 seedlings contained 42 mgms. P_2O_5, and 50 seedlings grown in the same quantity of soil-fertilizer mixture contained 35 mgms. Had the values of 100 seedlings been calculated from the fewer seedlings actually grown and analysed, the values would have been 56 mgms. and 70 mgms. for the thinner seeding. The growth of fewer normal seedlings per pot resulted in a relatively greater intake and, therefore, the calculations given in the Table below are misleading. However, the results, as obtained and calculated, though of no scientific value, are quoted in Table III as they show up how calculations of intake based on less than 95 seedlings of normal growth analysed and the lack of uniformity in technique, as has happened for this single series, have to be avoided. In a later series it was found that damage to the seed could be avoided by previously neutralizing the triple superphosphate with lime but the reduced solubility of the fertilizer resulted in the intake being about halved.

TABLE III

	Number of Normal Seedlings Analysed and Actual mgms. P_2O_5 in Shoots and Roots				Proportional Content in 100 Seeds		
		Shoots	*Roots*	*Total*			
Control Seedlings	98	20·85	5·60	26·45	26·93		
	98	20·82	5·13	25·95	26·67		
	89	17·11	4·26	21·37	24·10		
				Mean of two only 26·8 mgms.			
						Less 26·8 mgms. P_2O_5 in 100 Control Seedlings	Per cent Recovery of added Phosphate
150 mgms. or 1,000 p.p.m. P_2O_5 as sodaphosphate added to soil (150 grams)	91	36·63	5·25	41·88	46·02	19·22	12·8
	93	36·40	4·64	41·04	44·03	17·23	11·5
	89	35·76	5·37	41·13	46·21	19·41	12·9
Mean	—	—	—	—	—	—	12·4%
150 mgms. P_2O_5 as sodaphosphate dressed on to the seed.	90	30·54	5·71	36·25	40·27	13·47	9·0
	81	29·96	5·35	35·31	43·58	16·78	11·2
Mean	—	—	—	—	—	—	10·1%
150 mgms. or 1,000 ppm. P_2O_5 as triple supers added to 150 grams of soil.	92	32·97	5·57	38·54	40·23	13·43	9·0
	94	29·17	5·60	34·77	37·00	10·20	6·8
	98	31·73	5·80	37·53	38·30	11·50	7·7
Mean	—	—	—	—	—	—	7·8%
150 mgms. P_2O_5 as triple superphosphate dressed on to seed.	77	42·8	6·35	49·15	63·83	37·03	24·7
	74	41·21	5·37	46·58	62·95	36·15	24·1
Mean	—	—	—	—	—	—	24·4%

Other kinds of trials carried out, with brief statements on the results obtained, are given below to show how this pot culture method can be applied to study the 'early availability' of different kinds of phosphatic fertilizers under different conditions.

Example IV.—This trial was arranged to note the intake when two levels of sodaphosphate were dressed on to the seed as compared with placement in the soil. Wheat seedlings were grown in the Mau loam. Fertilizer containing 100 mgms. and 150 mgms. of total P_2O_5, equivalent to 500 and 750 p.p.m. when added to the soil, gave recovery values of 17.2 per cent and 17.6 per cent respectively. When similar quantities of sodaphosphate were dressed on to the seed, the amounts recovered were 9 per cent and 8.7 per cent. In this trial, the number of normal seedlings analysed varied between 95 and 99. The results confirmed that less phosphate is absorbed from sodaphosphate dressed on to the seed than when it is mixed with the soil.

Example V.—The recovery of P_2O_5 from ground Uganda Rock Phosphate was compared with that for two samples of sodaphosphate prepared from it, using rye grown in the Plateau loam. The recovery was 11 mgms. (5.5 per cent) from the Uganda Rock Phosphate supplying 30 mgms. 'citric-soluble' P_2O_5 and 31 mgms. (15.5 per cent) and 33 mgms. (16.5 per cent) from the two laboratory prepared samples of sodaphosphate supplying 144 mgms. and 154 mgms respectively, of 'citric-soluble' P_2O_5. In other trials with other soil types, the recoveries from the same sample of Uganda Rock Phosphate were 2 per cent in the case of a soil not requiring phosphate, and 3.7 per cent and 4.0 per cent with two phosphate-deficient soils. In all these trials, involving a total of 48 lots of seedlings, the number of seedlings of normal growth analysed amounted to 95 and over.

Example VI.—Using a more fertile sample of Kikuyu loam, the relative recoveries of P_2O_5 from another sample of Uganda Rock Phosphate containing 27.5 per cent of total and 4.7 per cent of 'citric-soluble' P_2O_5, was 5.7 per cent as compared with 21.4 per cent from sodaphosphate (22 per cent total and 18.5 per cent 'citric-soluble' P_2O_5) and 22.6 per cent from superphosphate.

Example VII.—Similarly, with rye grown in the Kipkabus loam which readily fixes water-soluble phosphates, the recoveries for the three same fertilizers quoted in Example VI, were 3.6 per cent from Uganda Rock Phosphate, 18.1 per cent from sodaphosphate, and 13.4 per cent from superphosphate.

Example VIII.—Again when the three same fertilizers were added to a better, darker soil, namely, the Molo loam which does not readily fix added phosphates, the recovery values were 2.4 per cent from Uganda Rock Phosphate, 20.4 per cent from sodaphosphate and 23.2 per cent from superphosphate.

Example IX.—This trial was made to note the relative amount of root-soluble phosphate that can be absorbed by wheat from increasing amounts of superphosphate, finely ground bonemeal, and finely ground Seychelles phosphate when these were added to the Molo loam. With 50, 100, 200, 400 and 800 p.p.m. of added total P_2O_5 supplied in the forms mentioned above, the percentage recoveries were 19, 18 per cent (discarded), 12 and 14 per cent from superphosphate; 14, 14, 8, 9 and 10 per cent from 100 mesh bonemeal and 8, 10, 7, 6 and 7 per cent from Seychelles phosphate. In many other similar trials with other soils, adding 1,000 p.p.m. total P_2O_5 the mean recoveries from these three materials were 16 per cent from superphosphate, 12 per cent from bonemeal and 8 per cent from Seychelles phosphate. The corresponding values when 1,000 p.p.m. of the same three fertilizers had been added to washed sand were 63 per cent for superphosphate, 10 per cent for bonemeal and 7 per cent for Seychelles phosphate. The recovery of P_2O_5 from superphosphate mixed with soils at the time of seeding is usually only about a quarter to a third of that recovered from sand, but bonemeal and Seychelles phosphate have about similar recoveries from both soils and sand.

Example X.—A trial was arranged to note the effect of the fineness of grinding of bonemeal on 'root-soluble' intake. This was done with wheat grown in the Molo loam. The same sample of bonemeal was successively ground to give four grades of fineness and a fifth coarse sample was prepared from weighed amounts of particular sievings. The percentages of P_2O_5 recovered, in order, with increasing fineness, were 1.8, 2.6, 4.2, 6.3 and 9.6 per cent. There was close agreement between the 'root-solubility' of the bonemeal and the fineness of grinding when this was expressed as the calculated surface area of the particles.

Example XI.—A further trial was arranged to note the effect of the time of application of bonemeal to some impoverished Kikuyu loam

in which wheat seedlings were grown. Bonemeal was mixed with the soil at the rate of 1,000 p.p.m. total P_2O_5 at 30 days, 20 days and 10 days before seeding—the soil being kept moist—and also at seeding time. The percentage recoveries were 3.3 per cent for −30 days, 4.6 per cent for −20 days, 7.2 per cent for −10 days, and 6.1 per cent when the bonemeal was applied at seeding time. When bonemeal was added beforehand, there was a corresponding decrease in the phosphate intake which was probably due to the decomposition of the nitrogenous portion and the partial fixation of the liberated phosphates. The lower intake for that given at seeding time is probably due to the lag before a sufficient breakdown of the bonemeal had set in, bearing in mind that the seedlings were withdrawn 18 days from seeding or 14 days after germination. With longer periods of growth, application as late as possible, that is, at seeding time, would appear to be necessary.

Example XII.—As it had been observed in the field that placement dressings of bonemeal encouraged local vigorous growth of new roots, whereas inorganic phosphates did not do this, a test was arranged to note the effect of the decomposition of this bone protein on the intake of phosphates. Two samples of bonemeal with 4.7 per cent and 3.8 per cent total nitrogen and also bone ash were used. The results with rye showed that the recoveries for the two samples of bonemeal were 17.5 per cent and 17.6 per cent but the bone ash showed a recovery of 5.3 per cent only. In this series comprising 12 plots, 98 or more normal seedlings were analysed, and there was very good agreement for replicate pots of each treatment.

Example XIII.—In another test, wheat was grown in the Kikuyu loam which had received 1,000 p.p.m. total P_2O_5 given as finely ground bonemeal placed in different one-inch soil horizons near and below the seed. These were near the seed, ½ to 1½ inches below, 1½ to 2½ inches below and 2½ to 3½ inches below the seed and also mixed throughout 4 inches of soil. The recovery value was highest for placement near the seed, when it was 6 per cent. It became less with successively greater depth of placement, namely, 4, 3 and 1.5 per cent and had the least recovery of 1 per cent only when the bonemeal was broadcast throughout the soil. It will be noted that when much of the young root system is allowed to extend into untreated soil, the recovery is much less than when it is all confined to the phosphate-enriched soil only. In this case, the highest recovery was 6 per cent as compared with about double this value in most other standard trials with bonemeal. The last three pot culture trials with bonemeal show that intake is greatest when finely ground material is placed near the seed at seeding time.

The method is now being used to note phosphate intake by maize and the sorghums and also to study the intake of calcium from soils receiving different treatments. It is bound to have application in the study of the true availability of residual soil phosphates of different kinds which have been built up folowing the addition of different classes of fertilizers, and in particular, Uganda Rock Phosphate, to different soil types over long periods.

It is appreciated that the intake of 'root-soluble' phosphates by the packed roots of cereal seedlings over a period of only some 14 days of growth, is not necessarily related to actual total intake over a season's growth in the field, or to the response in terms of yields. Much of the data obtained by this pot culture method of seeking particular information cannot at present be utilized to give sounder advisory services. It may be called basic data dealing with the 'solubility' of phosphatic fertilizers applied in different ways and the clues offered will have to be followed up by growing 'treated' crops to maturity under different field conditions. However, the method should offer better indications of phosphate availability than any partial chemical analysis of the fertilizers themselves or of soils which have received particular treatments. There will always be need for statistical field experiments to follow up certain pointers suggested by this kind of pot culture investigations.

ACKNOWLEDGMENTS

The work described in this paper has been done at different periods since 1935, mainly after 1943. In the early years, assistance was given by an African Laboratory Assistant, Mr. Peter Kamou, and later, in 1944, by Mr. J. Sperling of the East African Industrial Research Board, who was seconded for duties at the Scott Agricultural Laboratories. During 1948, Messrs. G. B. Rattray and E. G. Ward and, to a lesser extent, Messrs. G. M. F. Grundy and B. R. Norman, have carried out the numerous analyses of plant tissues. Full acknowledgment is made to the above mentioned for their participation in the work described.

APPENDIX

Details of the Technique of the Pot Culture Method

Alterations in the technique have been made from time to time as found necessary and that now described is not necessarily the ideal for the most accurate results but it does give reliable comparative data and most of the routine work involved can be carried out by trained African staff under proper supervision.

Materials required.—400-ml. squat beakers, 8-cm. lengths of 1-cm. glass tubing, cover glasses, pipettes, forceps, 3-mm. and 2-mm. sieves, plaster of Paris mould to hold 12 or 15 beakers, clean sand and rye or other seed of proved high germination.

Preparation and maintenance of pots.—It is necessary to have a standard method of preparing soil-fertilizer mixtures, seeding, watering, harvesting, and the analyses of the seedlings. If many series of trials are to be made with a particular soil, then it is necessary to put aside a sufficient quantity, say, up to 20 kilos of air-dry soil ground to pass a 2-mm. sieve.

Samples of 100 seeds of uniform weight are prepared, there being need for three more samples of seed than of pots in the series, as the determination of the total P_2O_5 in the seeds used is based on the mean of three analyses. The samples of seed are prepared first by the approximate weighing of 12, 15, 18, or more samples of 100 seeds of proved high germination. Then, after deciding on a convenient mean weight, the samples are adjusted to this weight by the process of exchanging larger seed for smaller ones and vice versa until the desired even weight for 100 seeds is obtained. Such weighings have to be done at about the same time, preferably early in the day, to avoid changes in weight due to changing humidity.

Nine, twelve, fifteen or some other multiple of three portions of soil, equivalent to 200 grams of oven-dry soil, are weighed out. Three portions are not treated and are used to grow the control seedlings, and three portions are used for each of the arranged treatments within the series. The mixing of soil and fertilizer is done in three successive stages, first using 5 grams of 40-mesh soil, then mixing with another 15 grams of similar soil and finally with the remaining soil. At the same time, 20 grams from each of the three untreated soils are ground to pass through a 40-mesh sieve and then mixed with the remaining soil. For comparative trials with different classes of fertilizers, it has been found convenient to use the equivalent of 1,000 p.p.m. total P_2O_5. Thus, 200 mgms. total P_2O_5 are added to each 200 grams of soil being treated.

The control and treated soils are spread out and usually 80 to 85 mls. of water are added evenly with a pipette. After soaking, the slightly caked moist soil is gently mixed and teased up with a spatula and then poured gently from tray to tray six times and finally passed through a 3-mm. sieve so as to break up any balls of moist soil. The granular soil is placed in its marked beaker in three portions with intermittent gentle standard tapping. The glass tubing is now placed in a prepared hole in the centre and the soil surface is made firm and even by being very slightly pressed down. Uniformity in technique will give a similar high pore space which makes for even and healthy seedling growth.

The seeds are now placed evenly on the soil surface with a pair of forceps and gently pressed down into the damp soil. In trials other than those including fertilizer dressed on to the seed, the seeds embedded in the treated soil are covered with 75 grams of dry, clean, medium sand, 50 mls. of water are added evenly with a pipette, and the covered beaker is left indoors until the seeds have germinated. As the seedlings tend to push up some of the moist sand, this is shaken down again and a further 25 grams of sand are added. When dressed seed is used it is covered with 50 grams of soil, treated as before and then 25 grams of sand are added, the pots are placed out of doors in the containing mould and watered at intervals when the soil has become fairly dry throughout and a few of the seedlings show the first symptoms of drought. Care is taken that only sufficient water is added to moisten the full depth of soil with no free water reaching to the bottom of the beaker. Any small excess is later pipetted out through the glass tubing and emptied out on to the sand.

Preparation of seedlings for analysis.—The soil is allowed to dry out towards the eighteenth day when the seedlings are harvested. After removing the glass tubing and pouring off the loose, dry surface sand, the seedlings are washed free of soil by a standard method. The moistened cylinder of soil and roots is loosened by hand and then dipped three times in one beaker of water and three times more in a second beaker, when most of the soil will have been

removed. The seedlings are then dipped six times in a succession of four beakers of water when it will be noted that the final washings do not become turbid and contain only slight traces of phosphate as shown by a colorimetric test. The separate seedlings are now disentangled and counted and again dipped three times to ensure that all soil and any phosphate particles which may have been held in the entangled roots are removed. All the washings are passed through a 2-mm. sieve and any dormant seeds and broken root portions are collected. The seedlings are now sorted out into 'seedlings of normal growth' (of standard development and size), and those of weak or dwarf growth. The seedlings of normal growth are counted and analysed and the weak seedlings are discarded.

Estimation of P_2O_5 content of seedlings.—The counted normal seedlings are analysed for their total P_2O_5 content by digestion with sulphuric and nitric acid, followed by the volumetric determination. As very many comparative phosphate determinations have to be made, it has been found expedient to use a simplified standard method of precipitation with ammonium molybdate done in a solution with 4 per cent nitric acid at 65°C. The precipitate contained in the Gooch crucible is washed three times with 1 per cent sodium nitrate and three times with distilled water. This standard technique and the use of sulphuric acid requires the adoption of a conversion factor of 1 ml. $\frac{N}{10}$ soda as being equivalent to 0.00029 gram P_2O_5. The author and others who have used this rapid method for many years have found that by using this factor it gives very good agreement with the more laborious official methods of phosphate determination. The P_2O_5 intake for particular soils made to assess phosphate requirements is the difference between the mean of that contained in triplicate lots of seedlings grown in the soil, based on 100 seedlings, and the phosphate contained in 100 seeds used.

In investigational work, arranged to note the root-solubility of fertilizers or the extra intake following particular treatments, the mean total phosphate content of three lots of seedlings grown in control pots of untreated soil is deducted from the mean total phosphate content of three lots receiving a particular treatment, calculated in all cases on how much phosphate 100 seedlings would absorb.

When extra phosphate is held or contained in the seed coat and cannot be washed out, such as when fertilizer dressed on to the seed, is included in the comparative treatments, it is necessary to analyse the shoot and root portions only, and the extra P_2O_5 content of these portions, based on 100 seedlings, is used. The percentage recovery is calculated on the amount of total P_2O_5 added to the soil.

A NOTE ON THE RELEASE OF SOME NEW CEREAL VARIETIES

By H. C. Thorpe, Senior Plant Breeder, Department of Agriculture, Kenya Colony

The following cereal varieties have been released to farmers from Departmental Control for sowing in 1949. All have been tested in Kenya firstly in small trial plots on the Plant Breeding Station, Njoro, altitude 7,100 ft., on the sub-stations at the Scott Agricultural Laboratories, 5,700 ft., at Rongai, 6,000 ft. and at Molo, 9,200 ft., and subsequently in large-scale field trials under farming conditions in various areas of the Colony. This, briefly, is the usual procedure adopted before any new variety is released to the farming community. Such large-scale trials besides serving to multiply the variety for subsequent issue, also enable characteristics such as straw strength and resistance to lodging, not always very easily seen in small experimental plots, to be more accurately gauged and make it possible to see how variety stands up to field conditions.

Notes on the breeding of the various cereals, their rust reactions, straw and grain quality, times to maturity and the upper limits of safe cultivation in Kenya are given below for each variety.

These cereals have been released through normal commercial channels, i.e. the Kenya Farmers' Association (Co-op.), Ltd., and farmers advised by notice in the Press to make application for their seed requirements direct to this firm.

Up to and including 1947 seven biotypes of black stem rust of wheat, *Puccinia graminis tritici*, had been isolated in Kenya. During 1948 a new biotype, called K8, has been found both in Kenya and in the Northern Province of Tanganyika. It is hoped to publish a note on the occurrence and isolation of this new physiologic form at a later date.

Wheat No. 318.*A.J.4.A*.1.

A selection out of the cross D.C. by Ceres 721 × 112.E.8.L.5, bred and selected at the Plant Breeding Station.

It is a beardless, white-chaffed, white-grained wheat of fair or better straw strength, maturing in approximately 5¾–6 months at Njoro, altitude 7,100 feet. It has full resistance to the eight biologic forms of black stem rust occurring in the Colony, is fairly resistant to leaf rust and shows resistance to yellow ear rust up to approximately 8,000 feet in Kenya.

318.A.J.4.A.1 has done well in large-scale field trials at Njoro and should be suitable to all areas in Kenya between 6,500–8,000 feet altitude, having a growing season of about six months duration.

The grain is acceptable to the mills.

Wheat No. 261.*R.7.C.1.B.*

A selection out of the cross 68.E.12.A.1 × Reliance, bred and selected at the Plant Breeding Station. It is a bearded, white-chaffed, light-red-grained wheat maturing in the same time as Kenya Governor, i.e. four months approximately at 6,000 feet altitude, in this Colony. The straw tends to be weakish.

It has full resistance to seven biologic forms of black stem rust occurring in the Colony and is probably resistant to the newest eighth form. It is fairly resistant to leaf rust and to yellow ear rust up to approximately 7,000 feet in Kenya.

This wheat has done well in large-scale field trials at Rongai during the 1948 season and should be suitable to all areas in the Colony between 5,000–7,000 feet altitude, having a growing season of about four months' duration.

The grain is of good quality and is acceptable to the mills.

Wheat No. 117.*A.II* (*Pure or Regenerated*).

Wheat 117.A was released to farmers in 1938 and replaced 58.F.(L.1) which was severely damaged by K.5 biotype of black stem rust in that year. It subsequently proved resistant to both forms K.6 and K.7 which appeared in 1940 and 1943 respectively, and it seems likely to show some resistance to the newest form K.8.

117.A has served Kenya well over a period of eleven years in areas of the Colony from 6,000 ft. to 8,000 ft. altitude, having a growing season of five to six months. Seed is now very mixed and it is with the intention of purifying the variety that this new selection has been released.

117.A.II is a single plant selection from 117.A selected and multiplied at the Plant

Breeding Station. Straw strength, disease reactions and grain quality are all roughly equal to those of the parent variety.

The selection, being the produce of a single plant, is pure and uniform. It has done well on a field scale in the Njoro and Rongai areas of Kenya and should be suitable for all districts in which 117.A is grown. It provides a source of pure seed for farmers who wish to renew their stocks of this wheat.

Wheat Rhodesian Sabanero.

Sabanero was imported into Kenya from South America in 1927. It was multiplied and released to farmers in 1934. At that time four biotypes of black stem rust had been isolated in the Colony to all of which Sabanero proved resistant. It has subsequently proved resistant to K.5 but has shown reactions in seedling tests bordering on susceptibility to K.6 and K.7 although it has not so far been damaged in the field. Seedling tests show a definitely susceptible reaction to K.8.

Sabanero, although of weak straw and possessing grain of poor quality, has served the Colony well over a period of fifteen years, during which time many new wheats had to be discarded on account of susceptibility to new physiologic forms of stem rust, and has up to date shown itself a valuable and dependable farmers' wheat. It is not yet known what effect K.8 will have on the wheat in the field.

Seed is now very mixed and the Rhodesian variety, multiplied up in Southern Rhodesia from a single plant, provides a source of pure seed. This selection, imported direct from Southern Rhodesia, has been under test in Kenya for a number of years and has done reasonably well in the Njoro and Eldoret areas of the Colony. It should be suitable to all areas in which Sabanero is grown, i.e. 6,000 ft.–8,500 ft. altitude in Kenya, having a growing season of 5–6 months' duration.

Straw strength, disease reactions and grain quality are all roughly the equal of the parent variety.

Glacier Barley.

A direct importation from the U.S.A. Glacier is a 6-row feed barley of good yielding powers and goodish straw. It matures in approximately 140 days at Njoro, altitude 7,100 feet.

It has done well in large-scale field trials in the Rongai and Njoro areas of Kenya and should be suitable for areas in the Colony from 5,000–8,000 feet approximately having a season of 4–5 months' duration. The barley is at present under test at altitudes over 8,000 feet.

Other New Varieties.

New varieties of wheat, barley and oats both locally bred and imported are constantly under test at Njoro. A note will be published from time to time on those found successful and released to farmers.

THE FAMILIES OF FRESHWATER FISHES OF TANGANYIKA TERRITORY, WITH A KEY TO THEIR IDENTIFICATION

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A KEY FOR THE IDENTIFICATION OF THE FAMILIES OF FRESHWATER FISHES OCCURRING IN TANGANYIKA TERRITORY

1.	Paired fins thin and whip-like (filamentous)	LEPIDOSIRENIDÆ
	Paired fins broad and flat, more typically fin-like	2
2.	Scales large, shining, bony and articulated (ganoid scales)	POLYPTERIDÆ
	Scales thin, horny and overlapping; with smooth hinder edges (cycloid scales) or with hinder edge finely toothed or ciliated (ctenoid scales)	3
	No scales	12
3.	Head covered with soft, thick skin hiding the bones of the gill-cover (opercular bones); scales small and thin	MORMYRIDÆ
	Skin of head relatively thin, with opercular bones visible; scales relatively large and thick	4
4.	A small keel or ridge of bony scutes on the abdomen	CLUPEIDÆ
	No such keel of scutes on the abdomen	5
5.	A small, fleshy fin (the adipose fin) behind the dorsal fin	6
	No adipose fin	7
6.	Lateral line nearer the ventral than the dorsal outline	CHARACIDÆ
	Lateral line along middle of side	CITHARINIDÆ
7.	No teeth in the mouth; mouth protractile	CYPRINIDÆ
	Teeth present in the mouth	8
8.	Dorsal and anal fins composed entirely of soft rays with no spines; mouth protractile	CYPRINODONTIDÆ
	Dorsal and anal fins with spines	9
9.	Body elongated and eel-like; a series of short detached dorsal spines in front of the dorsal fin	MASTACEMBELIDÆ
	Body compact and perch-like	10
10.	Two dorsal fins, the front one spiny	CENTROPOMIDÆ
	One continuous dorsal fin along the back, the greater part of it spiny	11
11.	One nostril on each side	CICHLIDÆ
	Two nostrils on each side	ANABANTIDÆ
12.	Rayed dorsal fin absent	MALAPTERURIDÆ
	Rayed dorsal fin present	13
13.	Rayed dorsal fin short, anal fin very long	SCHILBEIDÆ
	Rayed dorsal and anal fins very long	CLARIIDÆ
	Rayed dorsal and anal fins short	14
14.	Barbels on the mandible branched; a patch of long curved teeth on lower jaw	MOCHOCHIDÆ
	Barbels simple; all teeth very small	15
15.	Palate toothless; anterior nostril on upper surface of snout	AMPHILIIDÆ
	Palate toothed or, if toothless, with anterior nostril on upper lip	BAGRIDÆ

Tanganyika Territory, with parts of the three largest African lakes within its boundaries, and with a great variety of smaller lakes, swamps, rivers and other natural waters, has a large and varied fauna of freshwater fishes which seems but little known except to the specialist. Much work remains to be done on this interesting group of animals, not only

in the discovery of hitherto unknown species but also in the collection of information concerning the distribution and habits of even the commonest forms. Whereas the fish fauna of the larger lakes is now fairly well known there remain many other stretches of water to be investigated. In the hope of interesting local naturalists in the study of our freshwater fishes, some notes on the various families are given here in conjunction with a key for the identification of these families.

The key for identification is confined to the families; probably upwards of a thousand different species are already known from the Territory and identification as to species, especially in certain families such as the Cichlidæ, is often difficult except for the expert ichthyologist. There is no satisfactory general work for the identification of African freshwater fishes, but for those who wish to read further a short annotated list of more general works is given, as well as a few notes on the collection and preservation of fishes.

Only those families having indigenous representatives permanently resident in our inland waters are included here. I have excluded families of marine fishes which run up rivers, brackish-water fishes dwelling in estuaries and such introduced families as Salmonidæ (Trout) and Centrarchidæ (Bluegill Sunfish). Fishes known from Lakes Tanganyika, Nyasa and Victoria are included, whether actually recorded from our territorial waters or not.

In compiling this paper I am greatly indebted to Dr. E. Trewavas of the British Museum (Natural History) for much help and advice.

Notes on the Families

Lepidosirenidæ (Fig. 1 A) *Lung Fishes or Mud Fishes*

The Lepidosirenidæ, with three species in African and one in South American fresh waters, together with the single Australian species of the related family Ceratodontidæ, are the sole living representatives of the once extensive Order of Dipneusti, or Lung Fishes, which flourished in Palæozooic times.

The African Lepidosirenids are easily recognized by the long filamentous pectoral and ventral fins, quite unlike the usual type of paired fin. They are of rather eel-like appearance, with the continuous dorsal, caudal and anal fin giving the flattened hinder end of the body a leaf-like or spear-like aspect. The small scales are embedded in the skin and are invisible externally.

Protopterus æthiopicus, Heck, has been recorded from the Territory and occurs in Lakes Tanganyika and Victoria. This fish breathes air by means of lungs, except in the very young stages, and is able to live in streams and swamps which are completely dry for long periods of the year. With the approach of the dry season, *Protopterus* burrows into the mud and, with a slime secreted from its skin, it makes a hard cocoon. In this cocoon it æstivates until the next rains, breathing air by a small passage leading to the outside. Such cocoons, with a portion of the surrounding mud, have been dug up, transported overseas and the fish revived in water after a considerable period. One such specimen, taken to New York, was kept dormant for four years and then safely wakened.

Protopterus has heavy, plate-like cutting teeth and is omnivorous, its diet including smaller fish as well as snails, insects, etc. It can grow to a large size; a specimen of over six feet long has been recorded from Lake Victoria. This fish provides a favourite native food and is usually caught by long lines or traps.

Polypteridæ (Fig. 1 B)—*Bichirs, Reed-fishes*

The Polypteridæ, with about ten species confined to African freshwaters, are an interesting survival of a class of fish, the Palæopterygii, dominant in the Mesozooic. Their only living relatives of this class are the Acipenseridæ (Sturgeons) and the Polydontidæ (Spoonbills or Paddlefish), neither of these families occurring in Africa.

The Bichirs are easily recognized by the armour-plated appearance of their thick, enamelled, ganoid scales which are rhomboid in shape and are articulated by a peg-and-socket joint between the upper and lower edges of adjacent plates and by the possession of a series of dorsal finlets, each with an anterior spine.

Polypterus congicus, Blgr. has been recorded from Lake Tanganyika.

Clupeidæ (Fig. 1 E)—*Dagaa*

Most of the members of this important family are marine and include such familiar fish as the Herring and the Sardine.

The Clupeidæ are characterized by the absence of any spiny rays in the fins, by the

abdominal position of the ventral (or pelvic) fins and by the possession of a small ridge of bony scutes on the abdomen. This latter character, where not easily visible, can be detected by lightly drawing the finger along the abdomen towards the head. The Clupeidæ are generally surface-swimming, plankton-feeding fish, tending to occur in shoals.

This family is of great economic importance to our inland fisheries, for it is two species of Clupeid (*Stolothrissa tanganicæ* Regan and *Limnothrissa miodon* (Blgr.)) which comprise the *dagaa* of Lake Tanganyika. Many millions of these little whitebait-like fishes are caught and marketed annually. It should be noted that *dagaa* is a name also used of certain marine fishes caught at the coast and is also applied by natives on various inland waters to small and young fishes in general, but the true *dagaa* of the family Clupeidæ are restricted to Lake Tanganyika.

Mormyridæ (Figs. 1 C and 1 D)—*Snout Fishes*

The Mormyridæ, a family of over a hundred species confined to African fresh waters, are curious-looking fish with peculiar shaped heads which are covered with a thick, soft skin, reducing the gill-openings to small slits. They are mostly dull grey or bronze in colour and the scales are small and thin, lacking the iridescent sheen so characteristic of most fish scales. The eyes are small, and in many species the mouth is small and is situated at the end of a long tube-like snout which has given rise to the popular name of "snout-fish" or "elephant-fish" (this latter name is to be avoided, for it is also used of a marine fish, a Chimæra of the genus *Callorhynchus*). Some species possess rudimentary electric organs lying on either side of the end portion of the tail. These organs are defensive mechanisms and are of comparatively feeble power.

The Mormyrids are generally insectivorous, an important item in their diet being the bottom-living larvæ of "lake-flies" (Chironomidæ and Chaoboridæ), but they will also eat crustaceans, weed and organic debris and one species, *Mormyrops deliciosus* (Leach), a fairly important edible fish, preys on other fish. A familiar long-snouted species, *Mormyrus longirostris*, Peters, occurs in Lakes Tanganyika, Nyasa and Rukwa. The long snout is probably a modification for burrowing in the mud after small prey.

The Mormyrids are highly prized as food when caught by the natives, for they have few bones and are rich in oil. Hitherto they have not been caught in sufficient quantities to be of more than minor importance in the inland fisheries, but recent investigations on Lake Victoria have shown that there is an abundant population of these fish in the deeper waters of the lake below fifty feet, which has great possibilities.

Characidæ (Fig. 1 F)—*Characins, Tiger-fish*

This is a group of handsome fish, usually silvery in colour, with large scales and large and powerful teeth; even the small species of the family have the teeth well developed for the size of the fish. The Characidæ are distinguished from the closely related Citharinidæ by the position of the lateral line. Both these families have adipose fins, but the presence of scales and absence of barbels easily distinguishes them from the various families of Catfishes which may also possess this feature.

The most familiar fish of this family is that fierce and handsome predator, the Tiger-fish (*Hydrocyon lineatus* Bleek.), which gives such excellent sport with spinning or trolling in clear waters. This fish can attain a large size, but specimens of over 20 lb. are rare. Opinions on the edibility of the Tiger-fish vary, but the presence of many small bones in the flesh render it unpalatable to many. *Hydrocyon* is known from Lakes Tanganyika and Rukwa, but not from Victoria or Nyasa.

By no means all of the Characidæ are predators, a widely distributed species, *Alestes imberi* Peters, feeds on weed and the microscopic animal life of the surface waters (zooplankton).

Citharinidæ (Fig. 1 G)

The characters for separating this small group from the Characidæ have already been given but, in addition the Citharinidæ are generally deeper in the body than the Characidæ.

Two genera of this family have been recorded from Lake Tanganyika: *Distichodus*, which has comparatively strong teeth but ctenoid scales whose ciliated edges give the fish a dull appearance and make it rough to the touch, and *Citharinus*, which has weak teeth but cycloid scales with a smooth and shiny appearance.

These fish are gladly eaten by natives, but the Citharinidæ are of no importance in the fisheries of Tanganyika Territory.

Cyprinidæ (Fig. 1 H and I)—*Carps, True Barbels*

The Cyprinidæ are a very large family, widely distributed throughout the world and with many species in African fresh waters. The family is characterized by a scaleless head, a protractile mouth and the absence of teeth in the mouth. The teeth occur in the throat, on the sickle-shaped lower pharyngeal bones and bite against a horny pad at the base of the skull. These teeth show great diversity in their form and arrangement, dependent on the diet of the fish and the nature of these pharyngeal teeth is of some importance in classification. The many small species of the genus *Barbus* occurring in our waters are often difficult to identify. Many members of this family have small barbels, but are not liable to confusion with the scaleless Catfishes.

Some species of this family attain a large size and many are of definite economic importance. This is especially true in Lake Nyasa, where the *mpasa* (*Barilius microlepis*) is the most important food-fish at the northern end of the lake.

This family also includes small, silvery fish of the genus *Engraulicypris,* which are greatly prized by the natives as food and bait. Such fish are sometimes erroneously called *dagaa.*

Order Siluroidea—Catfishes

The various families of Catfishes of the Order Siluroidea are discussed together here for convenience; they were formerly considered to be all members of one family, the Siluridæ. The characters by which the different families are separated are given in the key. The fact that the Catfishes have no scales readily distinguishes them from the Characidæ and Citharinidæ, which also have adipose fins, and from the Cyprinidæ, which may have barbels. The Catfishes are often erroneously called "barbels" in this country, but this name should be reserved for the true barbels of the family Cyprinidæ.

The Catfishes are typically dwellers in confined, shallow, stagnant or muddy waters and are very tenacious of life when out of the water. Certain species possess accessory air-breathing organs.

The *Schilbeidæ* (Fig. 2 J) includes the species *Schilbe mystus* (Linn.), a predator which is widely distributed over the whole of tropical Africa and is known as the Butter-fish (a name which is also used of certain North American marine fishes). *Schilbe* has the head flattened in a horizontal, and the body in a vertical plane.

The *Amphiliidæ* are a small group of little importance.

The family *Bagridæ* (Fig. 2 K) contains a number of species of economic importance. Members of the genus *Bagrus,* which are predators, are of some importance in the fisheries of Lakes Victoria and Nyasa. *Auchenoglanis occidentalis* (Cuv. & Val.), which occurs in Lake Tanganyika, is a species greatly prized by the Northern Rhodesian natives of the Bangweulu region, yet this same fish is claimed to be poisonous by the natives of Lake Albert!

The *Clariidæ* (Fig. 2 L) possess accessory breathing apparatus in the shape of remarkable tree-like vascular structures in the air-chambers. They are of some importance in the inland fisheries, not only as food but in some cases by virtue of their nuisance value as predators on more valuable species of fish. *Clarias mossambicus* Peters, which is widely distributed throughout East Africa, is particularly plentiful in the shallow waters of Lake Rukwa, where it is known as *kambali.* It has recently been discovered that the liver of this fish is very rich in Vitamin A, an unusual feature in freshwater fishes. Some species of *Clariidæ* grow to a very large size; a specimen of *Heterobranchus longifilis* Cuv. & Val. landed recently from Lake Rukwa, was over six feet in length and weighed 125 lb.

Included in the *Mochochidæ* (Fig. 2 M) is a curious little fish, *Synodontis zambesiensis* Peters, which is variously known as the Trident-fish, Devil-fish, Squeaker or Grunter. All these names are derived from the presence of three serrated spines, one on the dorsal fin and one on each pectoral, which are capable of being locked at right-angles to the body and present a formidable defence against enemies. When this fish is caught, there is often an audible creaking of these spines in their sockets, hence the latter two names. A few species of *Synodontis* occurring in African rivers have the curious habit of swimming or floating upside down and have the normal coloration reversed so that the true upper parts are lighter, and the lower parts darker, in colour.

The *malapteruridæ* (Fig. 2 N) has but one species, the remarkable Electric Catfish, *Malapterurus electricus* (Gmel.), which has been recorded from Lake Tanganyika. This fish, which has a bloated appearance, is

greyish-yellow in colour, marked with brownish blotches and is capable of delivering a powerful shock. In contrast to other electric fishes, where the electric organs are localized and appear to be derived from a modification of muscular tissue, the electric organ of *Malapterurus* extends over the whole body and appears to have been derived from the inner layer of the skin. It takes the form of a thick coating of gelatinous material beneath the skin, containing many scattered electric plates. The hinder end of the fish is positive to the front end and the current passes from the tail to the head. The whole apparatus is controlled by a single fibre on each side, which arises from an enormous nerve-cell situated where the brain joins the spinal cord.

Except for a remarkable seasonal fishery in the Bahi Swamp, there is little large-scale trade in Catfishes in the Territory at present, but they are nevertheless of great economic importance as they are caught for food in small numbers by natives all over the Territory. Wherever there is a river, however transient, or a pond or swamp, however small, there are usually Catfishes to be caught. These fish are generally rich and oily and difficult to cure, but they provide an important item in the diet of natives far removed from the sea or the lakes.

Cyprinodontidæ (Fig. 2, O and P)—*Toothed Carps, Top Minnows*

This family of very small fishes, which superficially resemble the Cyprinidæ but have teeth in the mouth, usually have the tail fin rounded, the dorsal and anal fins set far back on the body and the scales extending on to the head.

On account of their small size, their often handsome appearance and curious habits, fish of this family are favourite subjects in aquaria. It is mostly Asiatic and American species that are so kept, although a few West African species have been studied in aquaria. An interesting and fruitful field of study offers itself here as far as our indigenous species are concerned.

Secondary sexual differences are common among the Cyprinodonts, the males being smaller and more brightly coloured. There is often a courtship ceremony. Many species are viviparous. Of especial interest is the habit of some species of feeding on mosquito larvæ. The absence of yellow-fever in Barbados was attributed to the presence, in the ponds and marshes, of a member of this family, the Millions-fish or Guppy (*Lebistes*). In different parts of the world, introduced Cyprinodonts, as well as indigenous species, have been successfully used for mosquito control. American species of *Lebistes* and *Gambusia* have been introduced into Kenya for this purpose.

Centropomidæ (Fig. 2 Q)—*Nile Perch, Sangala*

The *Centropomidæ* are easily recognized by the division of the dorsal fin into two, the front dorsal being heavily spined.

The true Nile Perch (*Lates niloticus* L.), does not occur in this territory, but several members of the family are known from Lake Tanganyika. Two closely related species of *Lates, L. microlepis* Blgr. and *L. angustifrons* Blgr., collectively known as *sangala*, give very good sport on the Lake and some very large fish have been landed.

Cichlidæ (Fig 2, R and S)—*Tilapia, Yellow-belly* (*Ngege*)

The continuous dorsal fin, the greater part of it spiny, which extends along the back in the Cichlidæ, distinguishes them from our other freshwater fishes with the exception of the Anabantidæ, which, however, possess two nostrils on each side as opposed to one in the Cichlids.

The Cichlidæ are by far the most important family of fish occurring in our inland waters. Not only are they the largest family in number of species, but it is members of this family, of the genus *Tilapia*, which form the most important food-fishes caught in the inland fisheries. Such fish are generally known as *ngege*, although "Tilapia" (from the scientific name) appears to be gaining currency among the European population; they are also sometimes erroneously referred to as "bream".

The African Cichlidæ appear to be evolving at a high rate and each of the main lakes possesses a very large number of endemic species. Lake Tanganyika has 90 to 100 species and Lake Nyasa 200 odd, yet these lakes have only one species in common and it is doubtful whether this species actually occurs in Lake Tanganyika proper and is probably confined to the rivers of the lake.

The genera and species of the family are frequently difficult to separate and dissection out of the pharyngeal teeth is often required for identification. In both Lakes Victoria and Nyasa, the major food-fish in each lake was

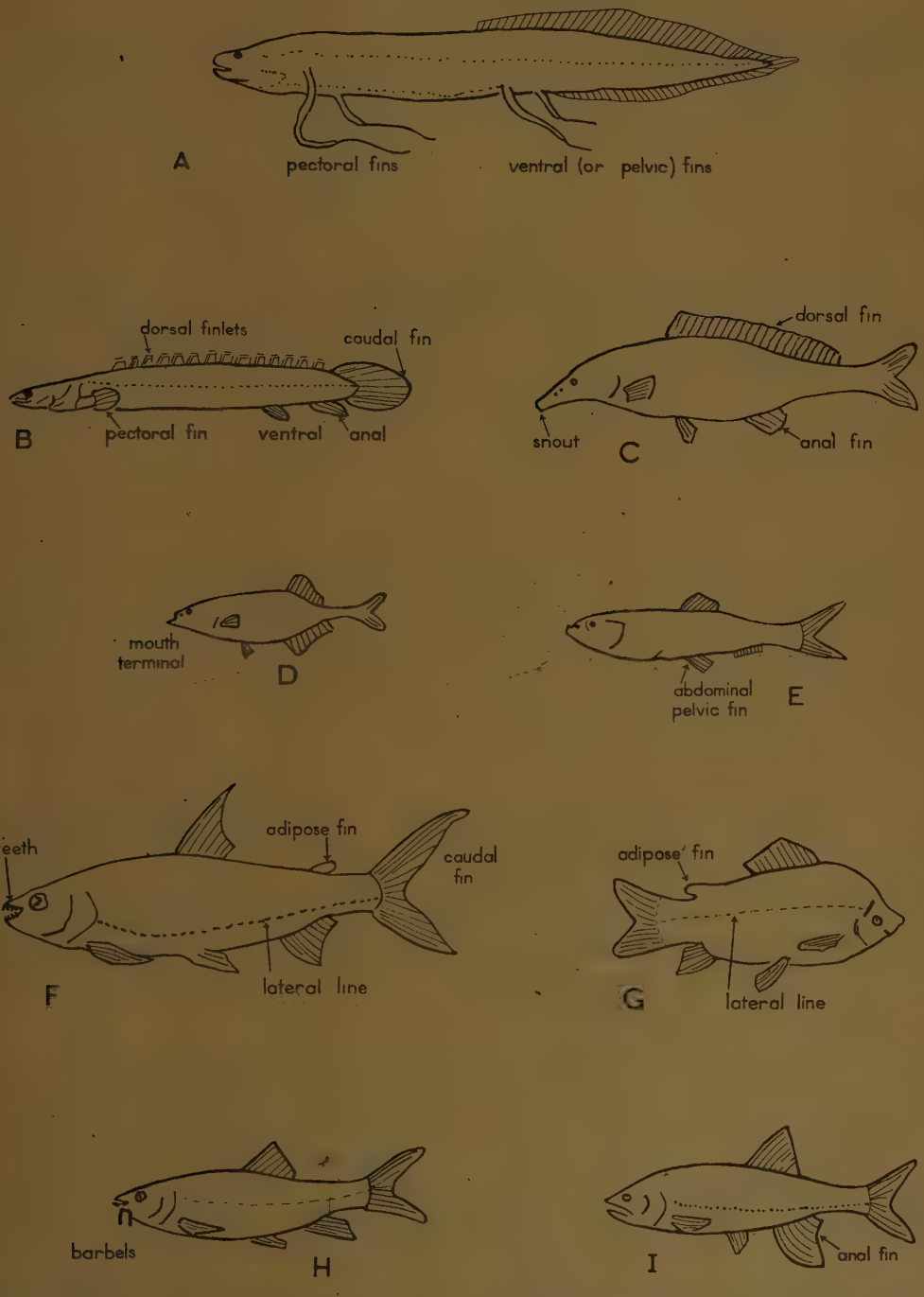

FIG. 1.—Outline drawings (not to scale) showing features of various families: (A) *Protopterus* (Lepidosirenidæ); (B) *Polypterus* (Polypteridæ); (C) *Mormyrus;* and (D) *Gnathonemus* (Mormyridæ); (E) Clupeidæ; (F) *Hydrocyon* (Chacacidæ); (G) *Distichodus* (Citharinidæ); (H) *Barbus*; and (I) *Barilius* (Cyprinidæ).

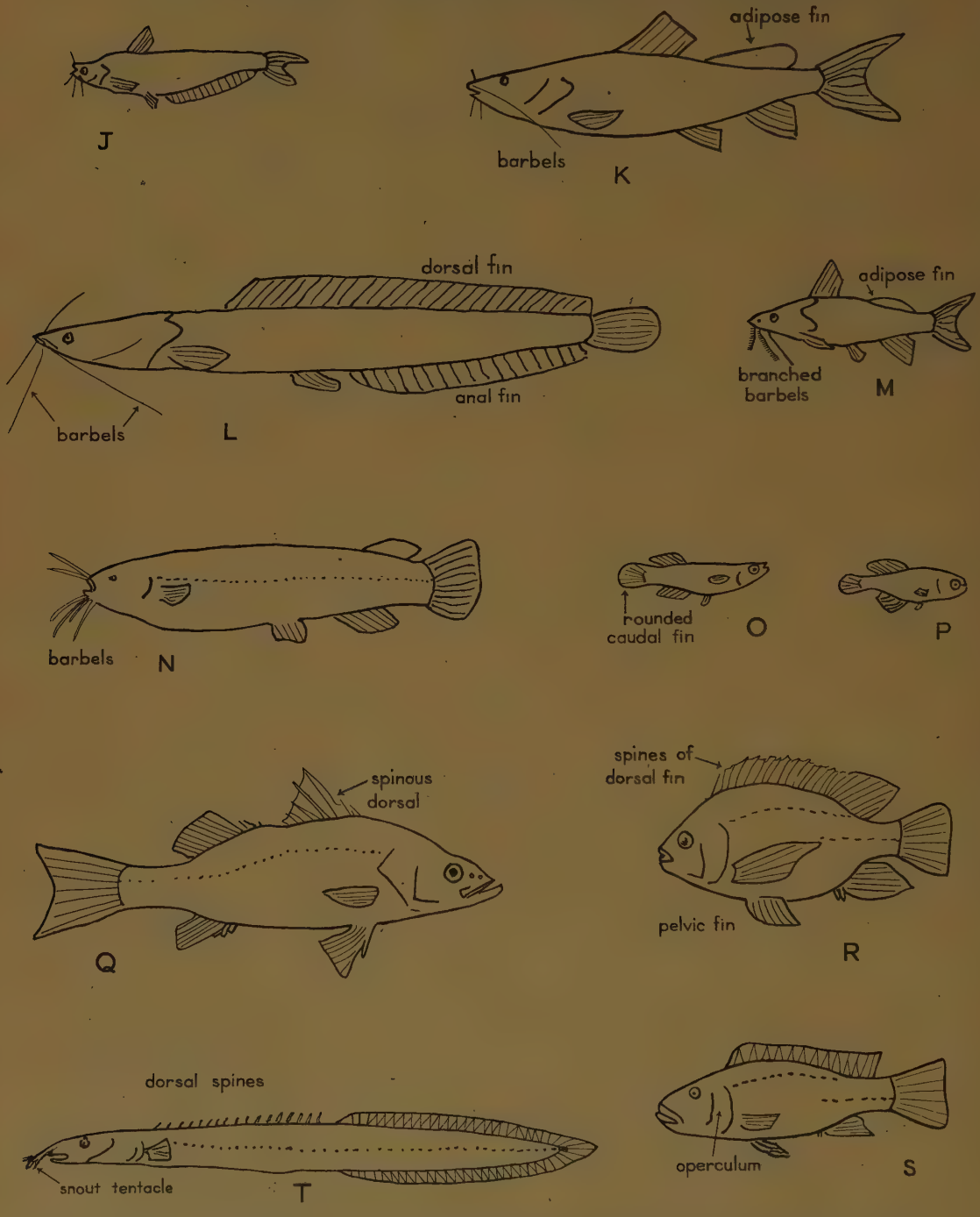

FIG. 2.—Outline drawings (not to scale) showing features of various families: *J. Schilbe* (Schilbeidæ); (K) *Bagrus* (Bagridæ); (L) *Clarias* (Clariidæ); (M) Synodontis (Mochochidæ); (N) Malapterurus (Malapteruridæ); (O) *Haplochilus* and (P) *Fundulus* (Cyprinodontidæ); (Q) *Lates* (Centropomidæ); (R) *Tilapia* and (S) *Serranochromis* (Cichlidæ); (T) *Mastacembelus* (Mastacembelidæ).

for many years thought to be a single species of *Tilapia*. Subsequent investigations have shown that there are two species of similar appearance in Lake Victoria and in Lake Nyasa, four species that look alike, plus two quite different species.

As may be expected in such a large and diverse family, there is a great variety of feeding and other habits. Some species are vegetarians, some feed on microscopic animal life, others are carnivorous. Some of the Cichlids, notably in the genus *Tilapia*, construct nest-depressions in shallow water for mating and egg-laying and some species may guard this nest. Such fish produce relatively few eggs and certain species will carry the eggs about in the mouth until they hatch and will also allow the young fry to return to the mouth in times of danger. Secondary sexual differences are common in the Cichlidæ, the male often assuming brilliant markings in the breeding season.

Cichlids of major economic importance in the Territory are *Tilapia esculenta* Graham and *T. variabilis* Blgr. from Lake Victoria and *T. rukwaensis* Hilg. & Papp. from Lake Rukwa. *T. squamipinnis* (Günther) and *T. lidole* Trewavas are the important species in Lake Nyasa, but the main fishery for these is at the southern end of the lake, around Fort Johnston and they are of little economic importance to Tanganyika Territory at present. The Yellow-belly, *Boulengerchromis microlepis* (Blgr.), a fine game-fish of Lake Tanganyika, is a member of this family. Cichlids have been used, with some success, for introduction into dams and other waters in East and Central Africa and the possibilities of these indigenous fish, both for food and sporting purposes, are often not realized by those who wish to introduce more vaunted species of exotic origin.

Anabantidæ—Labyrinthic Fishes

The Anabantidæ resemble the Cichlidæ, but apart from the possession of two nostrils on each side, they are generally longer in shape than the Cichlids and their scales are thicker and harder.

These fish are air-breathers and the name Labyrinthic Fish is derived from the possession of a labyrinth-like accessory breathing organ on each side of the head. The ability to breathe air renders these fish amphibious to a very limited extent and some species are able to travel short distances overland, progressing by means of the spiny gill-covers, pectoral fins and the tail. The so-called "Climbing Perch" (*Anabas*) of India, is a member of this family.

This small group are of no economic importance in our fisheries. Species of the genus *Ctenopoma* have been recorded from Lakes Victoria, Tanganyika and Nyasa.

Mastacembelidæ (Fig. 2 T)—*Spiny Eels*

Members of this family are easily distinguished by their eel-like appearance and by the row of short spines along the back in front of the dorsal fin. The Mastacembelidæ are not related to the true eels (Anguillidæ).

These fish are mostly carnivorous and it has been suggested that they burrow in the mud by day and search for food at night. The sense of smell seems to be of some importance. They have complicated olfactory organs and the nostrils are situated on a fleshy tentacle at the end of the snout.

Species of *Mastacembelus* are known from Lakes Victoria, Tanganyika and Nyasa.

NOTES ON THE COLLECTION AND PRESERVATION OF FISH

Little need be said about catching fish. A variety of methods such as lines, nets or traps may be used. Native fish poisons, such as *Tephrosia* or candelabrum *Euphorbia*, are an effective method of catching fish in small pools, but it should be noted that the use of these is normally illegal. In general, it may be said that large, striking or brightly-coloured fish are likely to be better known and of less interest to the specialist than smaller species of duller aspect.

By far the best preservative for fish is alcohol, such as industrial methylated spirit. A neutralized solution of 5 per cent formalin can be used, but it is not nearly so satisfactory although a preliminary bath of formalin (2 per cent is usually enough) for a few hours or overnight, before placing the fish in spirit, is a good thing. The final concentration of spirit to be aimed at is not below 70 per cent. This will entail, especially with larger fish, several changes of spirit which is weakened by the water contained in the body of the fish. The guts should be left in the fish, but a small slit should be made in the abdomen to allow the spirit to penetrate the body cavity or spirit can be injected into the body by a syringe via the mouth and vent.

Smaller specimens can be kept in corked glass tubes or in wide-mouthed, screw-top jars such as are used for fruit preservation. Larger specimens, wrapped in paper or cloth, can be soldered into a tin box or stored in an air-tight container of the milk churn type. When transporting or dispatching specimens, the container should be either filled right to the top with spirit or the contents just moistened before sealing. Any half-measures will lead to surging of the liquid with consequent damage to the specimens.

Every specimen should be accompanied by a label giving details of locality, altitude, date, method of capture, sex (if known) and any other relevant items such as the colour of the fish in life. Such labels are best written on unsized paper with a 2B pencil or on parchment paper with waterproof Indian ink.

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This work is now out of date in several respects and several of the volumes are out of print.

The following series of reports on the East African Lake Fisheries, written for the non-specialist, contain much useful information about the fish, including aids to their identification. All these reports are published by the Crown Agents for the Colonies, but unfortunately most of them are now out of print:—

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THE CUTTING AND TREATMENT OF SEED POTATOES*

By R. M. Nattrass, Senior Plant Pathologist, Department of Agriculture, Kenya

(*Received for publication on 4th March*, 1949)

That the potato can readily be propagated from various parts of the plant has long been known. The raising of potatoes from rose ends, sprouts, single eyes and cuttings has probably been practised since the early days of potato cultivation. Trials with potato peelings as seed were reported in the *Transactions of the Horticultural Society* as early as 1834 (Salaman, 1926). During the war years much publicity in the farming and gardening Press was given to this method of propagation pursued in Russia. Evans (1943) described a method of preparing potato "chips" for transport by air. The sending of potato eyes by post is an established method of distributing certified seed in the United States and Canada. In the United States cutting is a general practice. Large-sized tubers as much as eight ounces in weight may be cut into as many as ten pieces (Stuart, 1928).

In Kenya the subject of cut sets is important, the seed usually being obtained "as grown". The standard recommendation of planting whole tubers of about two ounces in weight or approximately the size of a hen's egg must be regarded as a counsel of perfection, particularly in view of the tendency of some potatoes in Kenya to form large tubers and the desirability of utilizing a high proportion of certain recently introduced stocks for seed. The general principles involved in the cutting of seed potatoes are described below.

The objections to cutting which have been put forward from time to time are that the yield per acre is less than when whole sets are used and that there are inevitably a number of misses due, in the main, to rotting of some of the pieces and unsatisfactory sprouting of others. The extent to which success is achieved by the use of cut seed pieces is dependent on the healing of the cut surface which is only fully developed under suitable conditions.

The process of the healing of the cut surface of the potato tuber was studied in detail by Priestly and Woffenden (1923). Immediately after cutting, the surface darkens in colour and in dry air forms a hard crust which readily cracks. The surface is usually coated with a white crystalline deposit consisting of salts and starch grains. There is considerable shrinkage and loss of moisture. This is evident when cut tubers are exposed to ordinary drying conditions. If, on the other hand, the cut surface is kept in a moist atmosphere, a different sequence of events occurs. Within 12–36 hours, the walls of the cells immediately below the cut surface become covered with a deposit of a varnish-like substance (suberin) which forms a continuous layer, blocking the cut surface. This not only prevents loss of moisture but effectively bars the way to rotting organisms such as bacteria and moulds. Within a further period, the duration of which depends on the variety of the potato and the temperature, the cells immediately below the blocked surface divide parallel to it to form a layer of suberized cells which eventually develops into a skin similar in structure and function to the outer skin of the tuber. Potatoes with the surface healed in this way show remarkable resistance to drying and can be treated as whole tubers. The time which elapses before the layer of cork cells is formed and the thickness of the layer varies with different varieties, some having the ability to form the layer more readily than others. The variety "Majestic", for instance, which is generally supposed to be a bad subject for cutting in these authors' experiments, formed a thinner layer than some other varieties. A Kenya variety showed a deposit on the cell walls 48 hours after cutting, but the commencement of the actual formation of the cork cells did not take place until the fifth day. Fig. 1 is a diagrammatic drawing of a section of a healed cut set, showing the formation of a layer of cork cells below the cut surface. That almost any part of the potato tuber can react in this way to wounding is shown by the fact that the tunnels made by the tuber-moth larvæ are lined with cylinders of cork cells, several cells thick, which effectively cut off and protect from bacteria the living tissue.

The above is the sequence of events which occurs under optimum conditions. It is dependent, in the first place, on the free flow of nutrients to the cells immediately below the

* This article originally appeared in this *Journal*, Vol. XI, 1945, p. 83, and is now repeated with an amendment and an addendum.—*Ed.*

cut surface and an atmosphere sufficiently moist to prevent evaporation. If the cut surface is exposed to dry air, a continuous layer of the deposit is prevented from forming. It occurs instead in isolated patches at different levels and is followed by irregular cork cell formation. The result is an inadequate protection against organisms and drying out of the flesh of the tuber. This is seen in Fig. 2. The half tubers, "A" and "B", were kept in a moist atmosphere for five days and then left exposed on the laboratory bench. The other halves of the tubers, "A.1" and "B.1", were similarly exposed without the moist atmosphere treatment. The photograph was taken one month after cutting. The drying and shrinking are much accelerated if the cut tubers are exposed to sunlight or drying wind.

The natural healing process can be induced by keeping the cut pieces in a moist atmosphere for 3–4 days after cutting. This can be done by placing the cut pieces in a shallow layer and keeping them covered with moist sacks or other material. As the healing is dependent on free access to oxygen, care should be taken that the cut surfaces are not actually lying in water.

For many years writers in various countries have recommended drying the cut surface of the tuber by dusting with lime, ashes or some other dry material. Priestly and Woffenden (1923) showed that no advantage followed this procedure. In fact, the quick drying of the cut surface interfered with the normal healing process.

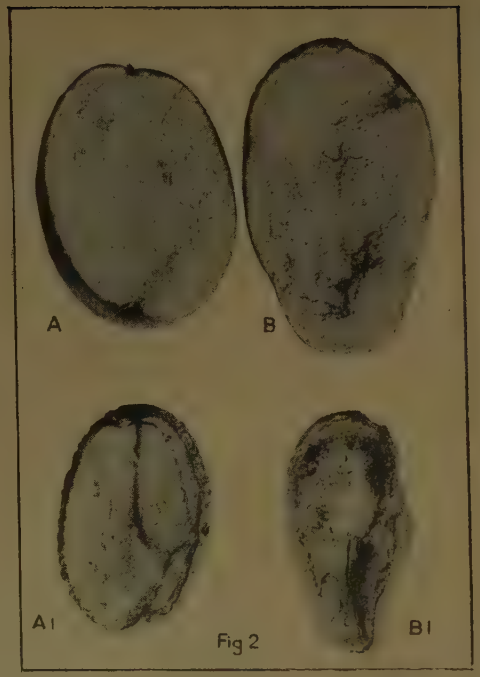
Within the last few years (as a result of wartime shortage of seed potatoes in the United Kingdom), the subject has been reviewed. A further series of experiments by Bell, Gilson and Dillon-Weston (1942) confirmed those of the previous writers. They pointed out that the chief objection to using cut sets was the poor establishment following the rotting of the cut pieces in the ground. This is attributed largely to the interference with the normal healing process when the surface of the cut tuber is allowed to dry before planting. The treatment of the cut surface with a disinfectant such as copper sulphate, or by dusting with lime, did not help the healing process. These writers emphasized, however, that the freshly-cut seed piece planted at once in moist soil heals rapidly enough to prevent the ingress of rotting organisms. Dillon-Weston and Taylor (1944) later reaffirmed previous findings on the strong healing powers of the potato tissue and showed that treatment by disinfectants may actually impair the process. Marritt (1944), however, found that potato eyes cut from tubers previously treated with an organic mercury dip gave a better stand than those from undipped tubers and that washing the cut sets with water was more reliable than dusting the cut surface. The most suitable packing was found to be moisture-tight packages in which sufficient moisture would be maintained to continue the healing process.

The practical implications of the above facts are clear. Cut tubers, if not to be planted immediately in moist soil, should be kept in a moist atmosphere for three or four days. Thus, in Cyprus, where the cut pieces are planted either in spring when the soil is naturally moist, or in summer when the land is irrigated, there is little loss from rotting of the seed pieces. On the other hand, as has been pointed out by Arnold (1941), in Rhodesia, where potatoes may be planted in dry soil some weeks before the rains, it is necessary to induce healing by the above method before planting.

That properly healed cut sets can withstand exposure almost as well as mature whole tubers is shown in Fig. 3. These cut sets were left exposed on the laboratory bench at Nairobi. The photograph was taken nine months after cutting.

Reference may here be made to the preparation of potato eyes as "chips". In experiments carried out at Kew (Evans, 1943), the cut pieces were kept in a storeroom at room temperature and showed a loss of weight of about 12 per cent after 24 hours and about 65 per cent after one week. It is stated that ten days after cutting, the pieces had shrivelled to about half the original size and looked like "slips of cardboard".

Applying the principles of healing described above, ten rose ends weighing about four grams each were placed on damp sand and kept in a moist atmosphere in a Rodewald germinator at room temperature (Nairobi). After four days the pieces were removed and weighed 40.2 grams. They were then left exposed for two months in the laboratory during the dry season. At the end of this period, the ten pieces weighed 30.9 grams, the loss of weight being rather less than 23 per cent. The photograph, Fig. 4, shows the condition of the pieces at the end of the period. Such pieces have been sent by air mail from Kenya to England



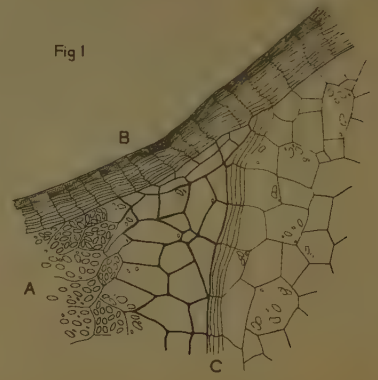


FIG. 1.—Diagrammatic representation of the healing of a cut tuber: A = Cut surface of tuber; B = Outer skin of tuber; C = Layer of cork cells formed below the cut surface.

FIG. 2.—Half tubers A and B healed in a moist atmosphere. A1 and B1 exposed on the laboratory table. (Photograph taken one month after cutting.)

FIG. 3.—Two halves of a cut and healed tuber after nine months exposure on the laboratory table.

FIG. 4.—The appearance of cut rose ends after ten weeks.

FIG. 5.—Plant from healed rose end planted six months after cutting.

By this method there is not the saving of weight for air transport which is achieved when the pieces are prepared as "chips" by the Kew method, but it is suggested that this may, on occasion, be more than compensated for by the length of time they can be kept before planting and their resistance to invasion by soil organisms.

It is generally agreed that the rose ends of halved tubers give better yields than do the heel ends. Experiments at Salisbury, Rhodesia (Arnold, 1941), showed a 50 per cent increase in yield from rose ends over heel ends. It is known that the developing sprouts which are first produced at the rose end inhibit the development of sprouts situated elsewhere. It is on this account that the usual practice is to cut the tubers longitudinally so that each half has a share of the apical eyes. This does not seem to be necessary if the tubers are cut when fully dormant. Large tubers can be cut transversely and longitudinally and will then produce good plants from each portion. If, however, sprouting has already begun the established practice of cutting longitudinally is to be preferred.

In Kenya, difficulty is frequently experienced in keeping seed potatoes from one crop until the next planting time. To prolong the keeping time as long as possible it is important that the tubers are mature with the skin set. In production of potatoes, especially for seed, cutting the haulm when the majority of the tubers has reached seed size and leaving them in the ground for two or three weeks will generally ensure a well-set skin. If these are then "greened" by exposure to diffuse light, the keeping quality will be improved. The period of dormancy is about three months, after which sprouting will begin. If the tubers are stored so that each is exposed to the light, short, sturdy sprouts will develop which will increase in length very slowly. Fig. 3 shows cut tubers nine months after cutting and healing.

Of particular importance to producers of both seed and ware potatoes in Kenya is the effect of exposure of the tubers to the direct rays of the sun. This, combined with the lifting of immature tubers, is responsible for considerable loss in the Kenya markets. It has been pointed out (Rose and Schomer, 1944) that in the U.S.A. much of the bacterial rot which occurs in transit and storage can be attributed to the effect of exposure to the direct rays of the sun. That this is generally realized in the States is the term "sunscald" applied to storage rots and blemishes in general.

Even when tubers are fully mature and the skins set, exposure to the sun for a short time will cause damage, the effects of which may not develop until some hours later. Tubers of the Kinongo variety kept at 40°C. for four days shrunk considerably and the flesh darkened and had a rubber-like consistency, while liquid oozed from the eyes. This temperature may well be exceeded in the field. Rose and Schomer (1944) also demonstrated, by means of infra red lamps, that tubers can absorb heat from such a source and develop a temperature several degrees higher than that of the surrounding air. At Nairobi in January, a thermometer inserted to the centre of a large tuber exposed to the sun registered, after three hours, a temperature of 50°C., while the air temperature over the tubers was only 32°C. Moreover, the temperature of the soil on which the tubers may be in contact at times reaches a temperature of 60°C., sufficient to subject them to mild cooking.

The damage caused by such exposure is more noticeable when the tubers are lifted before the skin has set and have suffered some skinning and bruising during handling. The unsightly dark brown skinned areas of potatoes seen in the Nairobi markets show that such maltreatment is by no means uncommon. The potatoes do not keep well; in bulk they tend to heat up and much loss is caused by bacterial rot, which first affects the tubers which have had their natural resistance broken down by heat.

Suberization or healing takes place on the skinned areas in much the same way as on cut surfaces. In the shade and shielded from drying wind suberization will occur in the outer cells and much shrinkage and loss of moisture may be prevented. Exposed to the sun or to a drying wind suberization occurs only at some depth below the surface.

Care is needed at lifting time and in dry weather potatoes should be bagged or suitably protected as soon as possible after lifting. If wet, they should be dried in the shade. Neglect of these precautions is one of the causes of the difficulty experienced in Kenya in storing potatoes for any length of time.

Since the original publication of this paper in 1945, further experimental work on the healing and protection of cut sets has

appeared. Bald (1947), in field trials in Australia, showed that the treatment of the cut sets with zinc oxide suspension (5 oz. to 1 gallon) reduced rotting and favoured suberization, whereas parallel mercury treatments injured the cut surfaces and permitted entry of rotting organisms.

Broadfoot (1947) carried out similar experiments on suberization and on the cutting of single eye sets. The experiments confirm that suberization takes place more readily in a moist than in a wet atmosphere. Treatment with fungicides is considered unnecessary if adequate suberization has occurred and that in the absence of suberization fungicides do not give a complete control of fungal infection.

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